INSTRUCTION MANUAL

Type 1564 Sound and Vibration Analyzer

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GENERAL RADIO

MP MASTER
MA33840

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WARRANTY

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel will be repaired or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

Type 1564 Sound and Vibration Analyzer

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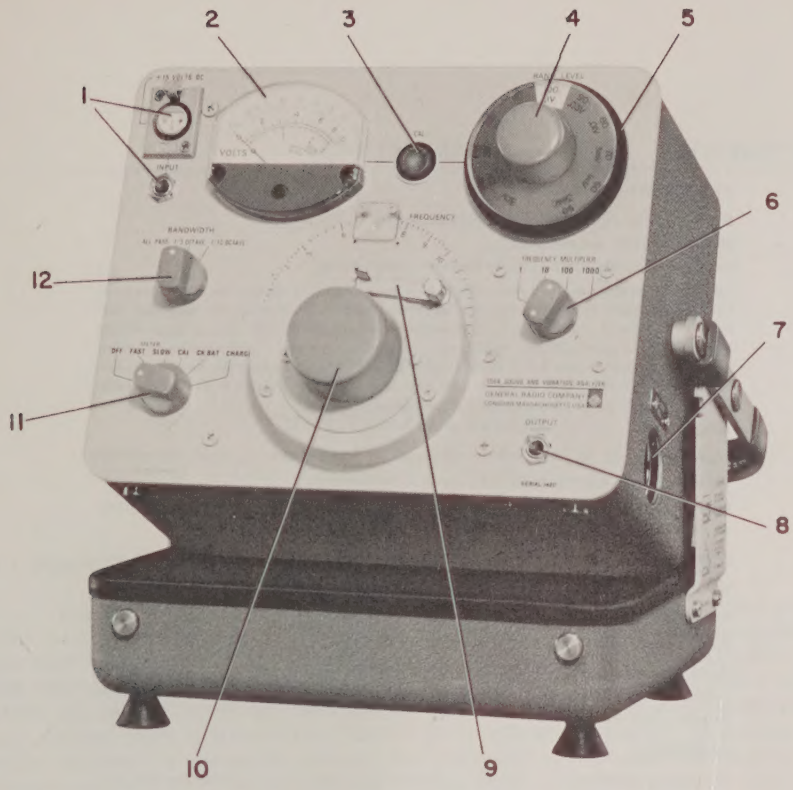

Figure 1-1. Type 1564-A Sound and Vibration Analyzer.

CONDENSED OPERATING INSTRUCTIONS

(Refer to Section 2)

CALIBRATION

a. Set BANDWIDTH switch to ALL PASS.

b. Set white dots on BAND LEVEL controls (both knob and dial) at "12 o'clock."

c. Turn function switch to CAL; wait 30 seconds.

d. Adjust CAL thumbset control to obtain meter reading in CAL region. Analyzer is now calibrated to read dB re 2 x 10^{-4} μbar, rms sound-pressure level.

NOTE

Always set both BAND LEVEL controls (knob and dial) fully cw as in step b, below, before proceeding with any measurement.

MEASUREMENT PROCEDURE

CAUTION

Always measure ALL PASS level before analyzing. Never adjust BAND LEVEL dial when analyzing.

a. Connect microphone to panel INPUT connector.

NOTE

For use of analyzer with 1560-P52 Vibration Pickup, refer to paragraph 2.7.

b. Turn both BAND LEVEL controls fully clockwise.

c. Set BANDWIDTH switch to ALL PASS.

d. Set function switch for FAST or SLOW meter response, as desired.

e. If meter reads above +10 dB, set BAND LEVEL knurled dial to give on-scale reading. If meter reads below 0 dB, adjust BAND LEVEL gray knob for + dB meter reading.

f. ALL PASS sound-pressure level is sum of readings on outer red scales of meter and BAND LEVEL indicator.

g. Turn BANDWIDTH and FREQUENCY controls to desired settings.

h. Adjust BAND LEVEL gray knob for on-scale reading.

i. Sound-pressure level in selected band (in dB re 2 x 10^{-4} μbar) is algebraic sum of meter and BAND LEVEL indicator readings.

CAUTION

Always use the function switch to turn off the instrument. Do not disconnect the line by external means only.

SPECIFICATIONS

FREQUENCY

Range: 2.5 Hz to 25 kHz in four decade ranges.

Dial Calibration: Logarithmic.

Accuracy of Calibration: ±2% of frequency-dial setting.

Filter Characteristics: Noise bandwidth is either 1/3 octave or 1/10 octave. One-third-octave characteristic has at least 30-dB attenuation at one-half and twice the selected frequency. One-tenth-octave characteristic has at least 40-dB attenuation at one-half and twice the selected frequency. Ultimate attenuation is 70 dB or greater for both characteristics. For both bandwidths, peak response is uniform ±1 dB from 5 Hz to 10 kHz and ±1.5 dB from 2.5 Hz to 25 kHz. An ALL-PASS, or flat, characteristic is also included.

INPUT

Impedance: 25 M in parallel with 80 pF (independent of attenuator setting).

Voltage Range: 0.3 mV to 30 V full scale in 10-dB steps.

Microphone: 1560-P6 Microphone Assembly or the 1560-P40K Pre-amplifier and Microphone Set is recommended.

OUTPUT

Voltage: At least 1.0 V open circuit, when meter reads full scale.

Impedance: Any load can be connected.

Meter: Three scales, 0 to 3 V; 0 to 10 V; -6 to +10 dB.

Recording Analyzer: Automatic range switching at the end of each frequency decade allows convenient continuous recording of spectra with the 1521-B Graphic Level Recorder.

GENERAL

Amplitude Calibration: Built-in, feedback-type calibration system permits amplitude calibration at any frequency.

Detector: Rms with three averaging times. Faster two speeds conform with USA standard for sound-level meters.

Power Required: Operates from 105 to 125 or 210 to 230 V, 50-60 Hz, or from nickel-cadmium battery supplied. Battery provides 25 h of operation when fully charged and requires 14 h for charging.

Accessories Available: 1560-P6 Microphone Assembly, 1560-P52, -P53, -P54 Vibration Pickups, 1560-P40 Preamplifier (power for preamp available at input connector), 1564-P1 Dial Drive for coupling to 1521 recorder for stepped third-octave analysis.

Mounting: Flip-Tilt case. Rack-mount version also available.

Dimensions (width x height x depth): Portable model, 10 1/4 x 8 1/8 x 8 in. (260 x 210 x 205 mm); rack model, 19 x 10 1/2 x 6 in. (485 x 270 x 155 mm).

Net Weight: Portable model, 14 1/2 lb (7 kg); rack model, 15 1/2 lb (7.5 kg).

Shipping Weight: Portable model, 17 lb (8 kg); rack model, 28 lb (13 kg).

Catalog Number	Description
	1564-A Sound and Vibration Analyzer
1564-9701	Portable Model
1564-9820	Rack Model

U. S. Patent Nos. 3,012,197, D187, 740, 2,966,257.
General Radio Experimenter reference: Vol. 37, Nos. 9, 10, pp. 1-9, Sept-Oct, 1963. Also, Vol. 41, Nos. 5, 6, May-June, 1967.

Handbook of Noise Measurement

This 260-page book, by Dr. A.P.G. Peterson and Ervin E. Gross, Jr., of the General Radio Engineering Staff, covers thoroughly the subject of noise and vibration measurement. Copies are available from General Radio at $2.00 each, postpaid in the United States and Canada.

Section 1
INTRODUCTION

1.1 PURPOSE.

The Type 1564-A Sound and Vibration Analyzer, Figure 1-1, is a portable instrument for the frequency analysis of voltages having components between 2.5 cps and 25 kc. The high input impedance of the analyzer permits the direct connection of piezoelectric transducers for the analysis of high-level acoustical spectra. For low levels, the analyzer can be operated in conjunction with a sound-level meter or a vibration meter. Designed for either manual or automatic tuning, the analyzer can be used with a graphic level recorder, such as the General Radio Type 1521, to produce continuous plots of level as a function of frequency.

1.2 DESCRIPTION.

The analyzer consists of three basic sections: preamplifier, filter, and output amplifier. The preamplifier section contains the amplification and attenuation necessary to change the input signal to a level convenient for filtering. Two cascaded resonant sections are used in the filter. These are either synchronously tuned to produce a bandwidth of 1/10 octave, or frequency-staggered to give a 1/3-octave bandwidth. The output amplifier section consists of amplifiers, 10-db-step attenuators, and a meter. The signal from the filter is amplified and is then used to drive the meter and to supply an output signal to a recorder, headphones, or other device.

The analyzer is continuously tunable from 2.5 cps to 25 kc in four decade ranges. It indicates voltages between 50 μvolts and 30 volts. Used with the accessory Type 1560-P6 Microphone Assembly or Type 1560-P5 Microphone, it indicates sound-pressure levels directly, between 44 db and 150 db re 2×10^{-4} μbar. With an accessory vibration pickup, Type 1560-P52, the analyzer measures acceleration from .0007 to 100 g.

Power for the analyzer is supplied by a 115- or 230-volt, 50- to 60-cycle line or by an internal, rechargeable, nickel-cadmium battery.

Both portable (Type 1564-A) and relay-rack-adapted (Type 1564-9820) models of the analyzer are available (see Figure 1-1).

The Type 1911-A Recording Sound and Vibration Analyzer, consisting of the Type 1564-A Sound and Vibration Analyzer and the Type 1521-B Graphic Level Recorder, with accessories, is also available.

1.3 CONTROLS AND CONNECTORS.

The following controls and connectors are on the Sound and Vibration Analyzer:

FIG. 1-1 REF.	NAME	TYPE	FUNCTION
1	INPUT	Three-terminal Cannon Type XLR locking socket paralleled by phone jack	Input connectors for either standard microphone plug or phone plug.
2	None	3-inch meter	Voltage and dB scales.
3	CAL	Rotary thumbset control	Adjusts gain for calibration.
4	BAND LEVEL (Gray knob)	6-position rotary switch	Adjusts gain of output amplifier in 10-dB steps and indicates meter range.
5	BAND LEVEL (Knurled dial)	6-position rotary switch	Adjusts level of input to filter in 10-dB steps and indicates meter range.
6	FREQUENCY MULTIPLIER	8-position rotary switch	Selects the frequency range and indicates the frequency multiplier.
7	Power cord receptacle 115 V, 50-60 Hz	3-terminal male connector	Input connector for line voltage, to operate instrument or charge battery.
8	OUTPUT	Phone jack	Supplies 1 volt open circuit for full-scale meter indication (6000 ohms output impedance).
9	None (Detent arm)	Nickel-plated arm, with finger	Engages detent at ASA-preferred frequencies.
10	FREQUENCY	Continuous rotary control and dial	Adjusts and indicates the geometric center frequency of the filter.
11	None (Function switch)	6-position rotary switch	Turns instrument on and OFF. Selects meter speed and mode of operation (CAL, CK BAT, or CHARGE).
12	BANDWIDTH	3-position rotary switch	Selects filter bandwidth.

1.4 CARRYING CASE.

The portable model of the analyzer is mounted in a Flip-Tilt case. The captive, protective cover serves as a mounting base when the instrument is in use. The friction of the rubber seal keeps the instrument at any convenient angle, from horizontal to vertical. Accessories, such as the Type 1560-P52 Vibration Pickup or the Type 1560-P41 Audio Frequency Voltage Probe, can be stored in the polyurethane compartment in the cover. (See Figure 1-3).

1.5 ACCESSORIES SUPPLIED.

The following accessories are supplied with the Type 1564-A Sound and Vibration Analyzer:

1 Type 1560-P76 Cable Assembly to connect to the output of a sound-level meter or vibration meter;

1 Type 1564-2020 Detented Knob-and-Dial Assembly, for use when the Type 1564-A Sound and Vibration Analyzer is used with the Type 1551-C Sound-Level Meter or with the Type 1553-A Vibration Meter.

1 Type CAP-22 Power Cord, P/N 4200-9622.

1.6 ACCESSORIES AVAILABLE (REFER TO THE APPENDIX).

1.6.1 TYPES 1560-P5 MICROPHONE AND 1560-P6 MICROPHONE ASSEMBLY (Figure 1-2). The Type 1560-P5 Microphone is a piezoelectric ceramic unit, mounted on a standard Cannon-type male connector. It can be plugged directly into the analyzer, or it can be connected to it by means of a length of shielded cable.

The Type 1560-P6 Microphone Assembly uses the same cartridge attached to a short length of flexible conduit. The assembly plugs directly into the INPUT connector on the panel of the analyzer.

Complete specifications for the Types 1560-P5 and 1560-P6 Microphones are given in the Appendix.

1.6.2 VIBRATION PICKUP SYSTEMS. Three vibration pickup systems are available; they differ in frequency range, sensitivity and impedance. Specifications for each of these systems (Types 1560-P11B, 1560-P13, and 1560-P14) are given in the Appendix.

1.6.3 TYPE 1560-P41 AUDIO FREQUENCY VOLTAGE PROBE. The Type 1560-P41 Audio-Frequency Voltage Probe is designed to permit voltage measurements on high-impedance circuits at a distance of about four feet from the analyzer. It consists of a 10-to-1, resistance-capacitance voltage divider enclosed in an insulated aluminum casing. A shielded cable from the divider terminates in a microphone connector that mates with the connector on the panel of the analyzer. Figure 1-3 shows the probe and the various tips that are supplied with it. The input impedance of the probe is 25 megohms in parallel with 20 pf, when the probe is connected to the analyzer. The probe attenuates the applied signal by 20 db. Therefore, the indicated voltage must be multiplied by ten.

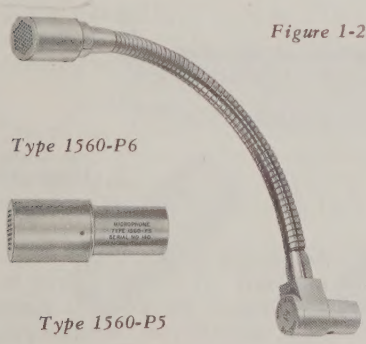

Figure 1-2.

Type 1560-P6

Type 1560-P5

Figure 1-3. Type 1560-P41 Audio-Frequency Voltage Probe is supplied with a variety of probe tips.

1.6.4 TYPE 1560-P40 PREAMPLIFIER. The Type 1560-P40 Preamplifier (Figure 1-4) is a high-input-impedance, low-noise preamplifier. It is particularly well suited for amplifying the output of piezoelectric transducers such as microphones and vibration pickups, and for driving long connecting cables without loss in signal voltage. A switch on the preamplifier provides a voltage gain of either 1:1 or 10:1.

Complete specifications are given in the Appendix.

The amplifier is housed in a small cylindrical case. The Type 1560-P5 Microphone cartridge plugs directly on to the input end of the case. Adaptors are available for connecting the preamplifier to the cartridge of the Type 1560-P3 Microphone, to GR874 Connectors, and to 3-terminal microphone connectors. Output from the preamplifier is through a 3-terminal shielded connector. The required dc supply voltage is applied from one of these terminals to ground. This voltage can be obtained directly from the Type 1564-A Analyzer.

The preamplifier and accessories are available in various combinations (refer to the Appendix).

The Type 1560-P40H Preamplifier and Power Supply Set is self-powered and independent of any external supply.

The Type 1560-P40J Preamplifier and Adaptor Set is dependent for its power on the instrument to which it is connected, so that it should be used with the Type 1558 or 1564 Analyzer.

The Type 1560-P40K Preamplifier and Microphone Set is for use with the Types 1558 and 1564 Analyzers when an acoustical measurement is needed at low levels and the microphone must be mounted at the end of a cable.

Type 1560-P40

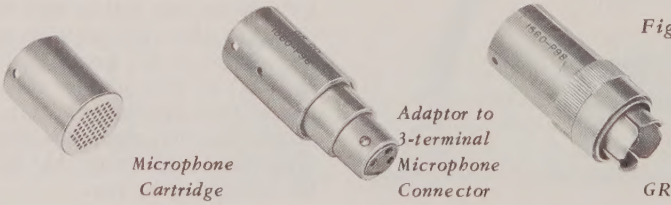

Figure 1-4.

Microphone Cartridge

Adaptor to 3-terminal Microphone Connector

Adaptor to GR874 Connector

Section 2

OPERATING PROCEDURE

2.1 OPENING THE FLIP-TILT CASE.

Directions for opening the Type 1564-A Sound and Vibration Analyzer are given on the handle of the Flip-Tilt case. Once open, the instrument can be tilted to any convenient angle, as shown in Figure 1-1. The instrument should be placed to give the most convenient access to the knobs and the best view of both the panel control settings and the meter indication.

The case can be locked fully open by means of the same slide pins that are used to lock it when it is closed. It can be carried in the open position, with the cover firmly in place.

2.2 POWER SUPPLY.

2.2.1 GENERAL. The Type 1564-A Sound and Vibration Analyzer can be operated from a 115-volt, 50- to 60-cycle line, from a 230-volt, 50- to 60-cycle line, or from its self-contained, rechargeable, nickel-cadmium battery. Normally supplied for 115-volt operation and charging, it is easily converted for use on a 230-volt line by changing the connections to the power transformer, as shown on the schematic diagram, Figure 4-2.

2.2.2 CHARGING THE BATTERY. To check the battery, turn the function switch to CK BAT. The meter should read in the area marked BAT. The battery will require charging after about 25 hours of operation.

To charge the battery, connect the Type CAP-22 Power Cord from the line to the three-prong connector on the right side of the case. The nameplate above the connector indicates the line voltage and frequency for which the analyzer is wired. Turn the function switch to CHARGE, and allow 14 hours to charge the battery fully.

2.2.3 OPERATION FROM THE LINE. Connect the analyzer to the line as in paragraph 2.2.1. With the function switch at CK BAT, the meter should read in the area marked BAT. The line now supplies power to operate the instrument; no charging is necessary.

CAUTION

The function switch must be used to turn off the instrument. Do not disconnect the line by external means only. If this is done, the instrument will continue to operate with battery power. Then it may be necessary to charge the battery for an hour or more before line operation can be resumed.

2.3 CALIBRATION.

The analyzer contains a built-in reference for gain calibration. The reference can be adjusted by means of an internal control (see Figure 2-1) which can be set in one of three ways, depending upon whether the analyzer is to be used with a microphone, with a vibration pickup, or as a voltmeter. The outer scale of this control is calibrated in db re 1 volt/μbar microphone sensitivity. Set this scale to indicate the sensitivity of the piezoelectric microphone to be used. The control is set in the General Radio laboratory to match the sensitivity of the microphone, if one is supplied with the analyzer. If the microphone is not ordered with the instrument, the control is set to the REF line. This setting is for operation with a Type 1560-P52 Vibration Pickup, which has a nominal capacitance of 10,000 pF, or for use as a voltmeter. The instrument can be made direct-reading in open-circuit volts for low-capacitance piezoelectric accelerometers such as the 1560-P53 (500 pF, nominal) or the 1560-P54 (900 pF, nominal) by setting the dial to the engraved dot that corresponds to the capacitance of the accelerometer. These dots, engraved 8, 4, and 2, Figure 2-2, correspond to capacitance values of 800, 400, and 200 pF, respectively. The REF position on the dial is used for capacitance values above 4000 pf.

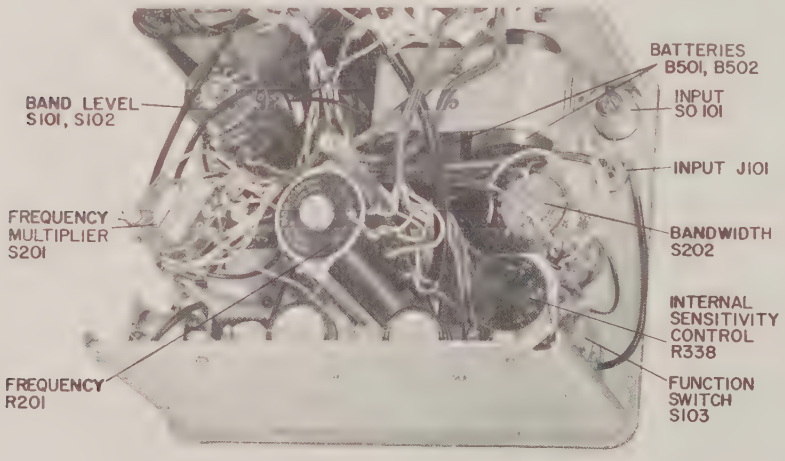

Figure 2-1. Interior view of analyzer.

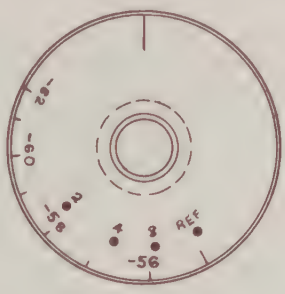

Figure 2-2. Dial for internal gain-calibration control.

2.4 OPERATION WITH TYPE 1560-P5 MICROPHONE OR TYPE 1560-P6 MICROPHONE ASSEMBLY.

2.4.1 CALIBRATION. Make the following check on the amplifier gain before using the analyzer. This check is valid only when the internal calibration control is set according to the instructions in paragraph 2.3.

a. Set the BANDWIDTH switch to ALL PASS.

b. Set the white dots on both BAND LEVEL controls (knob and dial) at the top (12 o'clock).

c. Turn the function switch to CAL and allow 30 seconds for the instrument to stabilize.

The meter should now indicate in the area marked CAL. If it does not, adjust it by means of the panel thumbset control marked CAL.

The analyzer is now calibrated for direct reading in db re 2×10^{-4} μbar, rms sound-pressure level. For some critical applications, this calibration can be repeated in a 1/3- or 1/10-octave band, at any selected frequency up to 10 kc.

NOTE

The calibration system is such that, with the function switch at CAL, a gain variation, as indicated by the meter, is ten times the actual gain variation. Therefore, when the analyzer is switched from ALL PASS to 1/3 OCTAVE or to 1/10 OCTAVE, the meter may indicate outside the CAL area. Also, tuning the analyzer in the CAL mode may cause the meter to vary over its entire scale, indicating a gain variation of about 1.5 db.

2.4.2 MEASUREMENT PROCEDURE.

a. Connect the microphone to the panel INPUT connector. Detents are provided in the connector of the Type 1560-P6 Microphone Assembly to hold it in place. The latter connector can be turned through 180°.

b. Turn both BAND LEVEL controls fully clockwise.

c. Set the BANDWIDTH switch to ALL PASS.

d. Set the function switch for the desired meter response, FAST or SLOW (refer to paragraph 2.17). Allow 30 seconds for the instrument to stabilize.

e. If the meter indicates above +10 db, turn the BAND LEVEL knurled dial to obtain an on-scale meter reading. If the meter indicates below 0 db, adjust the BAND LEVEL gray knob for a + db reading. The ALL-PASS sound-pressure level, in db re 2×10^{-4} μbar, is the algebraic sum of the readings on the outer, red scales of both the meter and the BAND LEVEL indicator.

f. Select the desired BANDWIDTH and FREQUENCY. A detent arm, located above the FREQUENCY knob, can be engaged to provide detents at the ASA-preferred frequencies (indicated on the tuning dial by white dots). To engage the arm, loosen the thumbscrew that fastens it to the panel. Slide the arm toward the knob by means of its protruding finger; then rotate the knob until the arm drops into its slot and tighten the thumbscrew.

The detent can be adjusted so that it selects any desired series of frequencies that are separated by 1/3 octave. First, engage the detent arm; then push the FREQUENCY knob toward the top of the instrument as far as it will go. Hold the knob in this position and turn the dial to any frequency in the desired series. Then release the knob.

g. Adjust the BAND LEVEL gray knob to obtain an on-scale meter deflection. The sound-pressure level in the band selected, in db re 2×10^{-4} μbar, is the algebraic sum of the meter and BAND LEVEL indicator readings. Special chart paper for plotting 1/3-octave band levels is available from Codex Book Company, Inc., Norwood, Massachusetts (Codex #31,462).

CAUTION

Improper use of the BAND LEVEL controls can overload the preamplifier and introduce errors. Always measure the ALL PASS level before analyzing. Never readjust the BAND LEVEL dial when you are analyzing. The procedure given in paragraph 2.4.2 ensures that the preamplifier is not overloaded and it allows the entire potential analyzing range of the instrument to be realized.

2.5 USE OF THE TYPE 1562 SOUND-LEVEL CALIBRATOR.

The calibrator of the Type 1564-A Sound and Vibration Analyzer does not check the microphone. For a calibration of the microphone-analyzer combination, the Type 1562 Sound-Level Calibrator is recommended. This calibrator includes a closed coupler and a driving loudspeaker, which produce a known sound-pressure level at the microphone. (Refer to the Operating Instructions for the calibrator.)

2.6 EFFECT OF PRESENCE OF OBSERVER AND INSTRUMENT CASE.

Except in reverberant fields, the presence of the observer and the instrument case can disturb the sound field and introduce significant errors[1]. To minimize this effect when the Type 1560-P6 Microphone Assembly is used, adjust the gooseneck assembly so that the microphone is located as far as possible from the observer and the instrument. The observer should stand with the analyzer in front of him, and with the sound source at his side. For greatest accuracy, mount the microphone (Type 1560-P5 or -P6) on a tripod and connect it to the analyzer by means of an extension cable. The observer and the instrument are thus removed from the sound field. Place the microphone so that the angle of sound incidence is 70° with respect to the microphone axis. This gives a response that corresponds to the random-incidence response.

2.7 OPERATION WITH TYPE 1560-P2 AND OTHER VIBRATION PICKUPS.

2.7.1 CALIBRATION. To calibrate the analyzer for use with the Type 1560-P52 Vibration Pickup, set the internal calibration control of the analyzer to REF and proceed as in para. 2.3 and 2.4.1. The analyzer is now set to indicate the rms value of the open-circuit pickup voltage.

2.7.2 PLACEMENT OF PICKUP. The design of the pickup enables it to be held in place against the vibrating object in any of several different ways. The preferred method is to attach it rigidly to the object with screws through the holes provided in the pickup or with a single screw threaded into the tapped center hole (1/4 - 28). Or the General Radio Type 1560-P35 Permanent-Magnet Clamp can be used. This is a disk-shaped magnet with a captive screw that can be threaded into the tapped center hole in the pickup.

If the vibrating object is flat and the level of vibration is low, the pickup can simply rest on the object.

For hand-held operation, either the round or the conical tip (both supplied with the pickup) can be used. These tips screw directly into the pickup or into the end of the six-inch probe which, in turn, screws directly into the pickup. Grasp the pickup (not the probe), and press it against the vibrating object only hard enough to prevent chatter. Hand-held operation is convenient and is recommended for exploratory measurements. However, the pickup should be firmly attached to the vibrating object if accurate results are desired.

A similar procedure can be used for other vibration pickups (para. 2.3 and 2.4.1).

2.7.3 MEASUREMENT PROCEDURE. Follow the instructions given in paragraph 2.4.2, steps b through g, but read the black, VOLTS, meter scale that corresponds to the setting of the BAND LEVEL control. The fullscale voltage sensitivity of the analyzer is indicated by the reading of the inner, black scale of the BAND LEVEL control. To convert the indicated voltage to acceleration in g's or inches/sec^2, divide by the sensitivity of the pickup in v/g or v/inch/sec^2, respectively. (Note: g = 386 inches/sec^2.)

[1] R. W. Young, "Can Accurate Measurements be Made with a Sound-Level Meter Held in Hand?" SOUND, 1, 1, 17-24, January-February, 1962.

2.8 USE WITH TYPE 1557 VIBRATION CALIBRATOR.

The Type 1557 Vibration Calibrator can be used to obtain an overall amplitude calibration at 100 cps. The calibrator is a self-contained electromechanical shaker that produces an acceleration of one g, rms, at a frequency of 100 cps with loads ranging from zero to 300 grams. The Type 1564-A Sound and Vibration Analyzer should indicate the sensitivity of the pickup being used multiplied by g. For example, for a 75 mv/g pickup, the analyzer should indicate 75 mv/g x g = 75 mv. If it does not, use the level indicated when converting from volts to g's. That is, if the analyzer indicates 60 mv, the sensitivity of the system (pickup and analyzer) is 60 mv/g. If a measurement shows a level of 1 volt, the corresponding acceleration is

$$\frac{1000 \text{ mv}}{60 \text{ mv/g}} = 16.7 \text{ g, rms}$$

2.9 DETERMINATION OF VELOCITY AND DISPLACEMENT FROM ACCELERATION MEASUREMENTS.

The following equations can be used to determine the rms velocity, displacement, and jerk of a given frequency component in a vibration spectrum when its rms acceleration and frequency are known:

$$v = \frac{a}{2\pi f} \qquad D = \frac{a}{4\pi^2 f^2} \qquad J = 2\pi f a$$

where a = acceleration in inches/sec^2
v = velocity in inches/sec
D = displacement in inches
J = jerk in inches/sec^3
f = frequency of component (frequency indicated by analyzer)
π = 3.14

The above equations are precise when used for a line (single-frequency) component; they give only approximate results for random signals.

2.10 USE WITH A STROBOSCOPE.

The Type 1564-A Sound and Vibration Analyzer can be used to trigger a stroboscope, such as the Type 1531 Strobotac® electronic stroboscope. The analyzer is first tuned to a particular component in the vibration spectrum and the stroboscope is then synchronized with that component. The output amplifier is overdriven so that the output waveform has sharp transitions. In this way, jitter caused by variations in acceleration amplitude is minimized.

To overdrive the output amplifier, first obtain an on-scale deflection of the meter, as described in paragraph 2.7.3. Then turn the BAND LEVEL knob to its maximum counterclockwise position. Do not change the setting of the BAND LEVEL knurled dial to increase the output, as this will overload the filter and render it ineffective.

2.11 OPERATION AS A TUNED VOLTMETER.

To calibrate the analyzer for use as a tuned voltmeter, follow the procedure given in paragraph 2.7.1 for use with the Type 1560-P52 Vibration Pickup. Thus calibrated, the analyzer indicates the level of the voltage applied at its INPUT terminals. When used with the Type 1560-P41 Audio-Frequency Voltage Probe, the analyzer indicates one tenth of the level applied at the probe. Proceed as in paragraph 2.4.2, except read the lower (black) meter scales. The inner (black) scale of the BAND LEVEL control indicates full-scale voltage sensitivity. Note that when the probe is used, indicated voltages must be multiplied by ten.

2.12 OPERATION WITH A SOUND-LEVEL METER.

2.12.1 GENERAL. A sound-level meter (such as the General Radio Type 1551-C) can be used ahead of the analyzer for band levels less than 44 db, sound-pressure level. Absolute band levels can be read directly from the analyzer when the Type 1564-2020 Detented Knob-and-Dial Assembly (supplied) is used.

2.12.2 CALIBRATION. The following procedure applies specifically to General Radio sound-level meters, but others can be used.

a. Remove the BAND LEVEL gray-knob-and-plastic-dial assembly; loosen the two setscrews that fasten it to the shaft and slide it off. Substitute the detented knob-and-dial assembly. One of the two setscrews in the latter secures the knob to the plastic dial and should not be loosened. Fasten the assembly to the shaft by means of the other setscrew.

To properly reset the original gray-knob-and-plastic-dial assembly, turn both coaxial shafts fully clockwise and set the assembly to read $\overset{100}{.1v}$.

b. Connect the sound-level meter to the INPUT jack of the analyzer; use the Type 1560-P76 Shielded Cable Assembly (supplied).

c. Set the BANDWIDTH switch to ALL PASS, the BAND LEVEL gray knob fully clockwise, and the function switch to FAST.

d. Calibrate the sound-level meter according to the instructions for that particular model, or use a Type 1552-B Sound-Level Calibrator. A calibration signal from the sound-level meter is now being applied to the analyzer.

e. Adjust the BAND LEVEL knurled dial and then the CAL thumbset control on the analyzer so that its meter indication is the same as that of the sound-level meter. The analyzer is now adjusted to indicate rms sound-pressure level in db re 2×10^{-4} μbar in conjunction with the sound-level meter. Do not readjust the BAND LEVEL knurled dial during the balance of the procedure.

2.12.3 OPERATION.

a. Set the BANDWIDTH control to ALL PASS and turn the BAND LEVEL gray knob fully clockwise, as in paragraph 2.12.2. Obtain an on-scale deflection of the sound-level meter with its weighting switch at 20 KC, and turn the clear-plastic BAND LEVEL dial in a clockwise direction until the BAND LEVEL indication (outer red scale) is the same as the attenuator setting on the sound-level meter. Both instruments now indicate the ALL PASS level.

b. Select the desired bandwidth and frequency, and adjust the BAND LEVEL gray knob for an on-scale meter deflection. The algebraic sum of the BAND LEVEL and meter indications is the level in the selected band in db re 2×10^{-4} μbar.

2.13 OPERATION WITH A VIBRATION METER.

2.13.1 GENERAL. For direct reading of velocity, displacement, or jerk, or when band levels are less than 0.0007 g (0.270 inches/sec^2), a vibration meter such as the Type 1553-A can be used. The inner scale of the detented knob-and-dial assembly and the two lower meter scales can be used to read directly acceleration, velocity, displacement and jerk.

2.13.2 CALIBRATION. The following procedure applies specifically to the Type 1553-A Vibration Meter. For other types, the procedure is similar.

a. The output impedance of the Type 1553-A Vibration Meter is 75 kilohms. When this impedance is loaded with the capacitance of the connecting cable and analyzer, a substantial high-frequency roll-off results. If frequencies above 1 kc are of no interest (for example, when a Type 1560-P52 Vibration Pickup is used) this error is of no consequence. With a wide-range pickup, such as the Type 1560-P53, connect a 10- to 20-kilohm resistor across the output of the vibration meter. This is done most conveniently inside the vibration meter. Remove the case and locate the 20-kilohm resistor that is wired to the output jack. Disconnect the end of this resistor that is wired to the center terminal of the jack and transfer it to the jack terminal to which the center conductor of a shielded cable is wired.

b. Remove the BAND LEVEL gray-knob-and-plastic-dial assembly; loosen the two setscrews that fasten it to the shaft and slide it off. Substitute the detented knob-and-dial assembly. One of the setscrews in the latter secures the knob to the plastic dial and should not be loosened. Fasten the assembly to the shaft by means of the other setscrew.

To properly reset the original gray-knob-and-plastic-dial assembly, turn both coaxial shafts fully clockwise and set the assembly to read $\frac{100}{.1v}$.

c. Connect the output of the vibration meter to the INPUT of the analyzer; use the Type 1560-P76 Shielded-Cable Assembly (supplied).

d. Set the BANDWIDTH switch to ALL PASS, the BAND LEVEL gray knob fully clockwise, and the function switch to FAST.

e. Calibrate the vibration meter according to its instructions or use a Type 1557-A Vibration Calibrator. A signal from the vibration meter is now applied to the analyzer.

f. Adjust the BAND LEVEL knurled dial and then the CAL control to obtain a meter indication on the analyzer that is 11% higher* than the meter indication of the vibration meter. For example, if the vibration meter indicates 8 on the upper scale, set the analyzer to indicate 8 + (0.11 x 8) = 8.9 on its upper scale. The combination is now calibrated to allow the analyzer to indicate rms band levels in the units given by the vibration meter when its METER READS switch is set to AVE. Do not readjust the BAND LEVEL knurled dial during the balance of the procedure.

2.13.3 OPERATION.

a. Fasten the vibration pickup rigidly to the vibrating object (refer to Type 1553-A instructions or paragraph 2.7 in this book for methods of fastening the pickup).

b. Set the METER READS switch to PK TO PK. Select the desired vibration quantity (DISP, VEL, ACCEL, or JERK) with the vibration meter FUNCTION switch. Adjust the SCALE SELECTOR switch for an indication on the vibration meter that is as near full-scale (but not over full-scale) as possible. The vibration meter now indicates the peak-to-peak level of the vibration quantity given by its FUNCTION switch. Do not readjust the SCALE SELECTOR switch during the balance of the procedure. Now, set the METER READS switch to AVE.

c. With the controls of the analyzer set as in paragraph 2.13.2, observe the reading in the FULL SCALE window of the vibration meter. Turn the clear-plastic BAND LEVEL dial on the analyzer in a clockwise direction to obtain this same reading (inner black scale). The vibration meter now indicates the average level of the over-all signal, while the analyzer indicates its rms level.

d. Select the desired analyzer BANDWIDTH and frequency. Adjust only the BAND LEVEL gray knob for an on-scale meter indication. The rms level in the band selected is read on the meter with the full-scale meter range indicated by the BAND LEVEL dial (inner black scale). The units of the vibration quantity appear in the window adjacent to the FULL SCALE window on the vibration meter.

2.14 OPERATION WITH THE TYPE 1560-P40 PREAMPLIFIER.

Use of the Type 1560-P40 Preamplifier increases the sensitivity to 24 db sound-pressure level and permits remote use of the microphone. (Refer to the Appendix for specifications.) The extremely high input impedance of the preamplifier extends the low frequency range when a low-capacitance pickup such as the Type 1560-P53 is used. The analyzer supplies power for the preamplifier through terminal #2 of the INPUT socket.

*The vibration meter indicates average level; the analyzer indicates rms level. These levels differ by 11% for the sinusoidal calibration signal.

Plug the preamplifier and microphone combination directly into the INPUT socket, or make the connection by means of a two-conductor shielded cable of convenient length. (Cables are supplied with the Type 1560-P40K Preamplifier and Microphone Set; they may also be purchased separately.) Set the gain switch on the preamplifier to X1 or X10, as desired. After calibration, the analyzer is direct reading with the gain switch at X1. When the switch is at X10, subtract 20 db from the indication of the analyzer to obtain the actual sound-pressure level.

When the microphone and preamplifier are used with the Type 1564-A Sound and Vibration Analyzer, the effective microphone sensitivity is increased. This increase occurs because the voltage loss caused by the preamplifier input-capacitance load on the microphone is less than that caused by the input-capacitance load of the analyzer. Also, when a cartridge from a Type 1560-P4 or -P6 Microphone is used, the loss due to the flexible arm is not present. (The sensitivity given for a Type 1560-P4 or -P6 Microphone is for the combination of the cartridge and the flexible arm.) The Type 1562 Sound-Level Calibrator is recommended for calibrating analyzer-preamplifier combination. However, the electrical calibrator in the Type 1564-A can be used if the internal sensitivity control, R338, is set properly. When the microphone cartridge is supplied with the Type 1560-P40 Preamplifier, or when it is removed from a Type 1560-P3 or -P5 Microphone for use with the preamplifier, set the sensitivity control to indicate 1.4 db greater than the specified sensitivity for the microphone. For example, if the sensitivity of the microphone or cartridge is -61 db, set the internal sensitivity control to -59.6 db (-61 + 1.4 db). When the microphone cartridge is removed from a Type 1560-P4 or -P6 Microphone Assembly to be used with the preamplifier, set the sensitivity control to indicate 2.1 db greater sensitivity than that specified.

2.15 BACKGROUND LEVEL.

Keep the background level as low as possible for all measurements. In any band, the level should be at least 10 db below the total measured level for that band. When this is impossible, apply the corrections given in Figure 2-3.

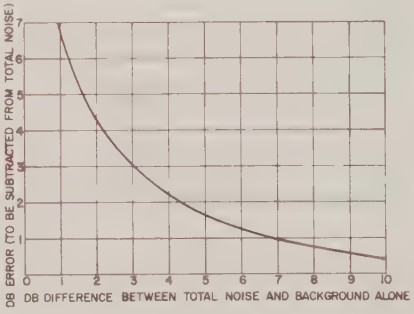

Figure 2-3. Effect of background noise on measurements.

2.16 CHOICE OF METER SPEEDS.

The averaging time of the meter depends on the settings of the BANDWIDTH and FREQUENCY MULTIPLIER controls, as well as on the setting of the function switch (FAST or SLOW). Three different detector characteristics are provided. In general, use the FAST position for measurements

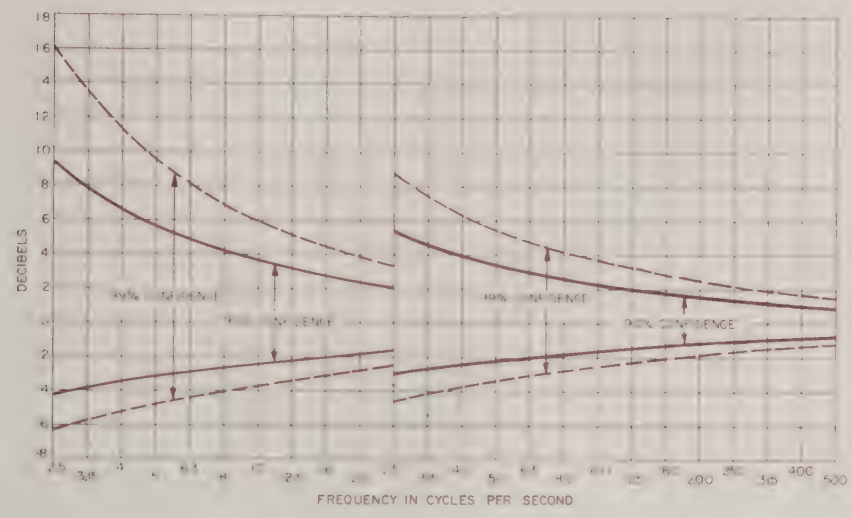

Figure 2-4, a. Confidence curves for 1/10-octave bandwidth with function switch at SLOW.

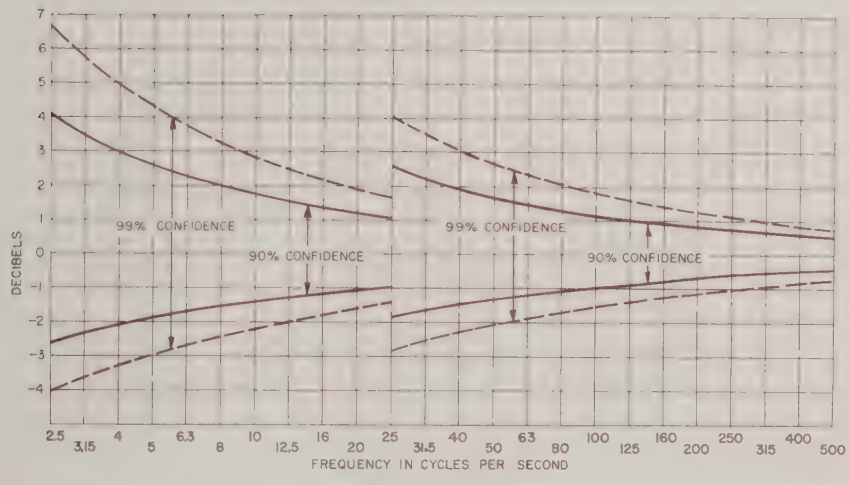

Figure 2-4, b. Confidence curves for 1/3-octave bandwidth with function switch at SLOW.

TABLE 2.

METER SPEEDS OBTAINABLE WITH VARIOUS SETTINGS OF THE FREQUENCY MULTIPLIER (See Text)

FREQUENCY MULTIPLIER SETTING	SPEED RANGE (FUNCTION SWITCH)	
	FAST	SLOW
1	2	3
10	1	2
100	1	2
1000	1	2

on line spectra, and the SLOW position for measurements involving random signals, except possibly in the 2.5- to 25-kc range. Table 2 gives the speeds obtainable with various settings of the FREQUENCY MULTIPLIER switch when the function switch is at FAST or SLOW. The values in the table apply for BANDWIDTH switch settings of 1/3 or 1/10 octave. The speeds are numbered; 1 is the fastest speed and 3 is the slowest. Speeds 1 and 2 are designated *fast* and *slow*, respectively, by the American Standards Association Specification S1.4-1961 for General Purpose Sound Level Meters. Speed 1 has the symmetrical rise-and-fall characteristics of the meter movement. The characteristics for speeds 2 and 3 are those of simple resistance-capacitance networks. For speed 2, the rise- and fall-time constants are 0.4 and 1.2 seconds, respectively; for speed 3, they are 2 and 6 seconds.

With the BANDWIDTH switch set to ALL PASS, the speeds corresponding to the FAST and SLOW positions of the function switch are 1 and 2, respectively.

Figure 2-4 can be used to determine the probable error in a given meter indication when the reading fluctuates, as it does for a random signal. The curves apply only when the function switch is set to SLOW. From the curves labelled 90% CONFIDENCE, we find that there is one chance in ten that the long-time rms level (which would be indicated if the meter did not fluctuate) is below the observed level by more than the number of decibels at the lower limit, or is above the observed level by more than the number of decibels at the upper limit. For example, assume that a random signal produces fluctuations of the meter, with the function switch at SLOW, the BANDWIDTH switch at 1/10 OCTAVE, and the analyzer tuned to 5 cps. Suppose the meter indicates a level of +4 db. Then, for a 1/10-octave band centered at 5 cps, there is one chance in ten that the long-time level is more than +9.7 db or less than +0.8 db.

The 99% CONFIDENCE curve can be used similarly to find the levels that will be exceeded only one percent of the time.

To determine, with greater confidence, the level of a fluctuation signal, a number of readings are taken at intervals of several detector time

constants. These readings are then averaged. Confidence limits, in this case, can be determined by dividing the limits for a single reading by the square root of the number of readings taken.

2.17 ALL-PASS FREQUENCY RESPONSE AND EFFECTS OF MICROPHONE AND VIBRATION PICKUP.

The all-pass frequency response of the Type 1564-A Sound and Vibration analyzer for a constant applied voltage contains a slight roll-off at the frequency extremes when the function switch is set to SLOW (See Figure 2-5). In addition, when the function switch is set to FAST, the detector characteristic becomes average for frequencies below 25 cps, resulting in a 1-db step in the response curve, as shown. Neither this low-frequency step nor the high-frequency roll-off are cascaded with the filter when 1/3- or 1/10-octave bandwidths are selected.

Figure 2-5 also gives the responses of the analyzer-microphone and analyzer-pickup combinations. In each case the low-frequency roll-off is due to the loading of the capacitive impedance of the transducer by the 25-megohm input resistance of the analyzer. Deviations at high frequencies are characteristic of the transducers. Both of these response curves may be considered to cascade with the 1/3- and 1/10-octave filter characteristics.

2.18 OPERATION WITH TYPE 1521 GRAPHIC LEVEL RECORDER.

2.18.1 GENERAL. The analyzer contains an automatic range-changing device that permits continuous amplitude-versus-frequency recordings when it is used with a Type 1521-A or -B Graphic Level Recorder. These two

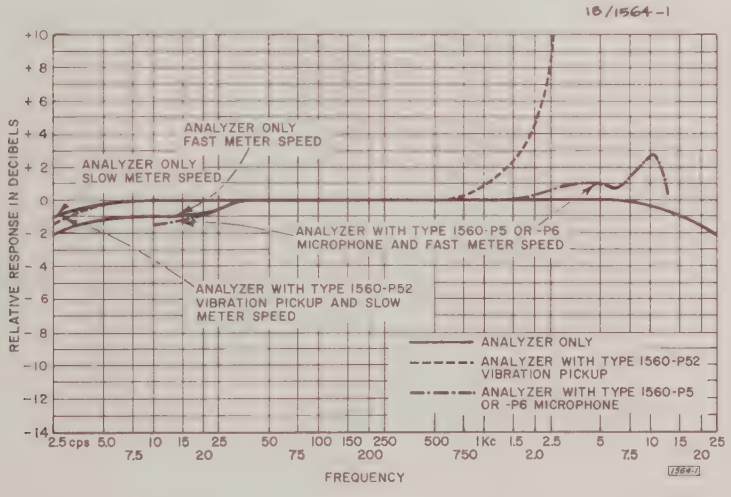

Figure 2-5. Curves of frequency response for constant applied voltage.

models differ primarily in frequency range. The Type 1521-A can be used down to 20 cps; the -B model is usable to 7 cps or lower, if a correction is applied. Two chart papers, differing in length and in scale factor (the product of db/inch on the vertical scale and inches/decade on the horizontal scale, expressed in db/decade), are available for use with either recorder. The Type 1521-9469 chart paper has a length of five inches/decade resulting in a scale factor of 50 db/decade (a proposed international standard) when the 40-db recorder potentiometer (normally supplied) is used. The Type 1521-9493 chart paper has a length of 7.5 inches/decade and a scale factor of 75 db/decade with the 40-db potentiometer. A Type 1521-P10B Drive Unit and a Type 1521-P15 Link Unit are required to couple the analyzer to the recorder. In addition, when Type 1521-9469 chart paper is used, the 24-tooth sprocket normally supplied with the Type 1521-P15 Link Unit must be replaced with a 16-tooth sprocket. The latter is available as part of the Type 1521-P16 Sprocket Kit.

The Type 1521-P2, 40-db Potentiometer is supplied with the recorder; Types 1521-P1 and -P3 potentiometers are also available for amplitude ranges of 20 db and 80 db, respectively.

Three different motors are available for the recorder, to permit various sweep rates. The medium-speed motor, Type 1521-P23 (Type 1521-P24 for 50-cycle operation), is recommended for general use with the Type 1564-A Sound and Vibration Analyzer, but the fast-speed motor, Type 1521-P19 (Type 1521-P21B for 50-cycle operation), can be used. Table 3 gives the possible recorder chart speeds and analyzer sweep speeds for each motor, with either a 24- or a 16-tooth sprocket.

The completely-assembled analyzer-and-recorder combination is available as the Type 1911-A Recording Sound and Vibration Analyzer. This assembly includes the following items:

1—Type 1564-9820 Sound and Vibration Analyzer (rack model).
1—Type 1521-B Graphic Level Recorder, with medium-speed motor.

TABLE 3.

RECORDER CHART SPEEDS AND CORRESPONDING ANALYZER SWEEP SPEEDS.

FAST-SPEED MOTOR			MEDIUM-SPEED MOTOR			
Chart Speed Inches/Minute	Sweep Speed Decades/Minute		Chart Speed Inches/Minute	Sweep Speed Decades/Minute		
	24-Tooth Sprocket With Type 1521-9493 Chart Paper (7.5 Inches/Decade)	16-Tooth Sprocket With Type 1521-9469 Chart Paper (5 Inches/Decade)		24-Tooth Sprocket With Type 1521-9493 Chart Paper (7.5 Inches/Decade)	16-Tooth Sprocket With Type 1521-9469 Chart Paper (5 Inches/Decade)	8-Tooth Sprocket With Type 1521-9471 Chart Paper (2.5 Inches/Decade)
75	10	15	15	2	3	6
25	3 1/3	5	5	2/3	1	2
7 1/2	1	1 1/2	1 1/2	1/5	3/10	6/10
2 1/2	1/3	1/2	1/2	1/15	1/10	2/10

1—Type 1521-P10B Drive Unit.
1—Type 1521-P15 Link Unit, with 16- and 24-tooth sprockets.
10—Rolls, Type 1521-9469 Chart Paper.
1—Type 1560-2140 Adaptor Cable (insulated double plug to offset phone plug.

Also available – Type 1521-9471 Chart Paper (refer to Table 3).

2.18.2 INSTALLATION.

NOTE

The Type 1911-A Recording Sound and Vibration Analyzer is fully assembled when delivered. The following installation procedure applies only when the analyzer and recorder are ordered separately.

Figure 2-6 shows the portable Type 1564-A Sound and Vibration Analyzer in its Flip-Tilt case, mounted above the Type 1521 Graphic Level Recorder. The relay-rack-model analyzer (Type 1564-9820) can also be mounted over the recorder. To couple the two instruments, proceed as follows:

(a) Remove the FREQUENCY control knob-and-plate assembly that is fastened to the dial cover with a screw on each side of the knob. Also remove the detent-arm assembly (held by a thumbscrew, 4, Figure 2-6).

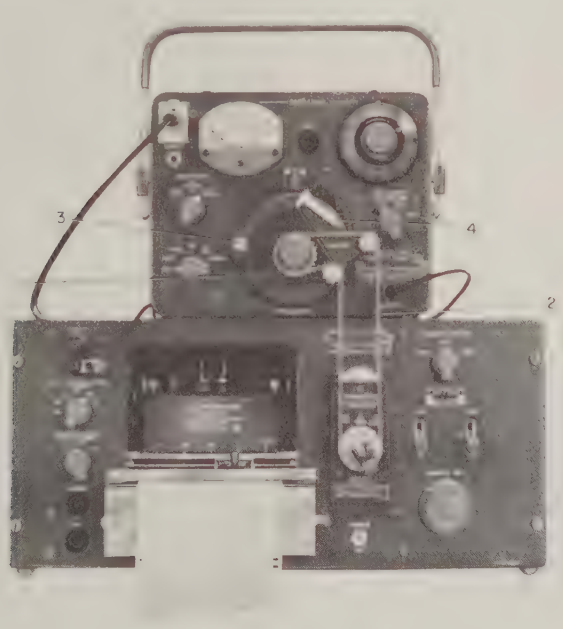

Figure 2-6. The Type 1564-A Sound and Vibration Analyzer with the Type 1521 Graphic Level Recorder.

(b) Using the screws removed in (a) (omit the washers), fasten the Type 1521-P15 Link Unit (1) in place of the knob assembly. Adjust the unit to allow slight backlash when the sprocket is turned. Replace the detent-arm assembly.

(c) Install the chain (2) as shown in the figure. Two chains are supplied with the link unit. Use the short chain with the analyzer in its Flip-Tilt case; the long chain must be used with the relay-rack model. To tighten the chain, loosen the locking screw (3), rotate the sprocket plate to take up most of the slack, and retighten the screw.

2.18.3 OPERATION. The Operating Instructions for the Type 1521 Graphic Level Recorder include a complete discussion of its operation with an analyzer. Set the external-motor switch to the position toward the rear of the instrument, for continuous operation of the recorder.

If the analyzer-recorder combination is to resolve faithfully the complex variations in a spectrum which it is capable of resolving, certain rules regarding sweep speed (chart speed) and writing speed must be observed. A sweep speed that is too fast will cause errors in the recorded amplitude, center frequency, and bandwidth of the filter. If the writing speed is too slow, errors may result due to the inability of the recorder to follow sharp contours in the spectrum. Table 4 gives the recommended maximum sweep speeds and corresponding minimum writing speeds for the various ranges of the analyzer. For the Type 1521-B Graphic Level Recorder, the low cut-off frequency is raised as the writing speed is increased; therefore a maximum writing speed is also imposed for each frequency range, and these are included in the table. Note, also, that the 20-cps low-frequency cut-off of the Type 1521-A Recorder prohibits its use in the lowest (X1) frequency range. Slower chart speeds and correspondingly slower sweep speeds are recommended when a faithful time-averaged plot of the spectrum is desired.

TABLE 4.

MAXIMUM SWEEP SPEEDS AND CORRESPONDING MINIMUM WRITING SPEEDS FOR ANALYZER-RECORDER COMBINATIONS.

Range (Frequency Multiplier)	Maximum Sweep Speed (Decades/Minute)	Minimum Writing Speed (Inches/Second)	Maximum Writing Speed Type 1521-B Recorder Only (Inches/Second)
Type 1521-B Recorder Only 1	1/5	1	3
10	1 1/2	3	10
100	5	10	20
1000	5	10	20

Section 3
PRINCIPLES OF OPERATION

3.1 GENERAL.

The various sections of the Type 1564-A Sound and Vibration Analyzer are described in the following paragraphs. Reference should be made to the elementary schematic diagram, Figure 3-1.

3.2 PREAMPLIFIER SECTION.

The high input impedance of the preamplifier section permits the amplifier to be driven by any of a variety of transducers, including piezoelectric microphones and accelerometers. The first stage of this section uses two transistors (one of which is a field-effect transistor) to produce an amplifier with an input impedance of 25 megohms, a low output impedance, and a stable gain of about 3 db. Directly before and after the preamplifier are the step attenuators, which are operated by the BAND LEVEL knurled dial. Their purpose is to change the input signal to a level convenient for analyzing.

The continuously adjustable attenuator, operated by the CAL control, is included in this section. A Cannon female connector and a phone jack, connected in parallel, provide convenient connections to various sources.

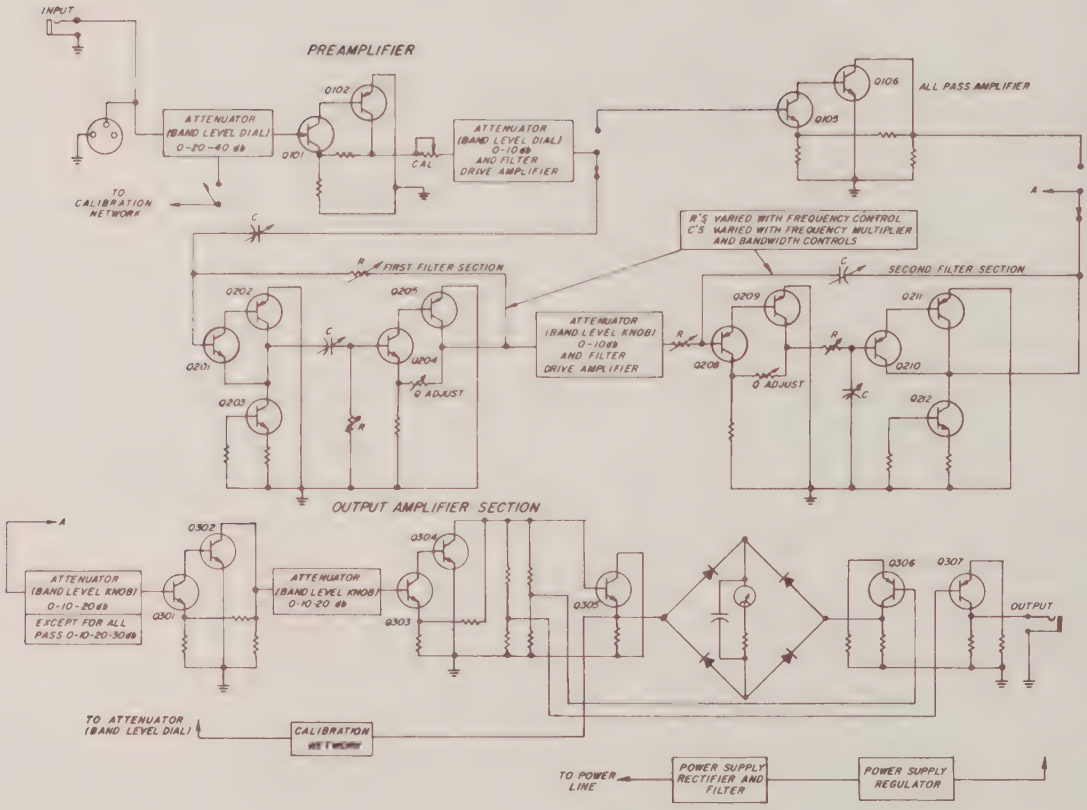

Figure 3-1. Elementary schematic diagram of the Type 1564-A Sound and Vibration Analyzer.

3.3 FILTER SECTION.

The filter is synthesized as an isolated cascade of two resonant (second-order) sections. The resonant frequencies of the sections are staggered about the selected center frequency to produce a filter having a noise bandwidth of one-third octave. To obtain a one-tenth-octave response, the sections are synchronously tuned. A functional diagram is given in Figure 3-2, and Figure 3-3 shows the amplitude-versus-frequency response for each bandwidth. The plot was produced automatically by a Type 1521 Graphic Level Recorder and Type 1304-B Beat-Frequency Audio Generator.

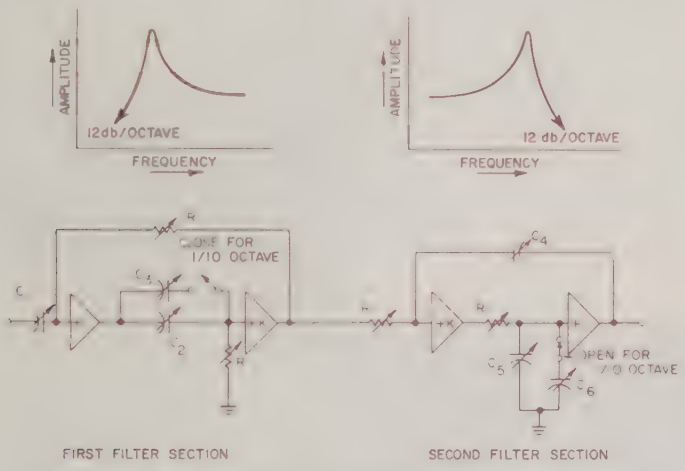

Figure 3-2. Elementary schematic diagram of the filter sections.

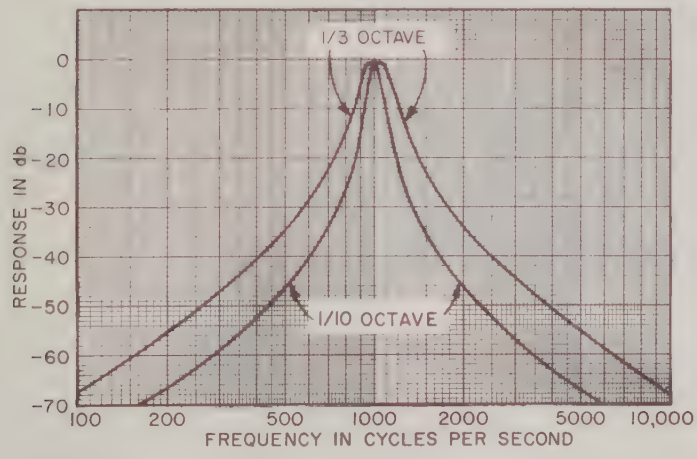

Figure 3-3. Filter response characteristics.

The capacitors C1 through C6 are switched by the FREQUENCY MULTIPLIER control and determine the tuning range. The four resistors, R, are adjusted simultaneously by the FREQUENCY control to span the ten-to-one range selected. Frequency responses that are mirror images of each other are the result of interchanged placement of resistors and capacitors for the two sections. Attenuation rates approach 12 db/octave at low and high frequencies for the first and second filter sections respectively. A symmetrical over-all filter response is thus obtained. For one-third octave operation, the resonant frequency of the first filter section is 16% higher than that of the second. When the one-tenth octave bandwidth is selected, C3 is added in parallel with C2, and C6 is removed from across C5. These changes bring the resonant frequencies of the sections together and increase the Q's.

The response of the filter to a transient is shown in Figure 3-4. The input signal consisted of a burst of 32 cycles at 1 kc. The filter was tuned to 1 kc for both the 1/3- and 1/10-octave bandwidths. The rise time (time required for the output signal to rise from 10% to 90% of its steady-state value) and the fall time (time for the signal to fall from 90% to 10%) were 4 milliseconds for the 1/3-octave filter and 9 milliseconds for the 1/10-octave filter, at the test frequency of 1 kc. Figure 3-5 is a plot of the rise and fall times versus the center frequency, for the two bandwidths.

Top curve: Output for 1/3-octave bandwidth

Second curve: Input

Figure 3-4. Response of filter to a transient.

Third curve: Output for 1/10-octave bandwidth

Lower curve: Input

3.4 ALL-PASS AMPLIFIER.

A separate broad-band amplifier (Figure 3-1) is substituted for the filter when the BANDWIDTH switch is set to ALL PASS. This permits measurement of the unfiltered signal level so that the coaxial attenuator can be adjusted for the greatest signal-to-noise ratio of the filtered signal.

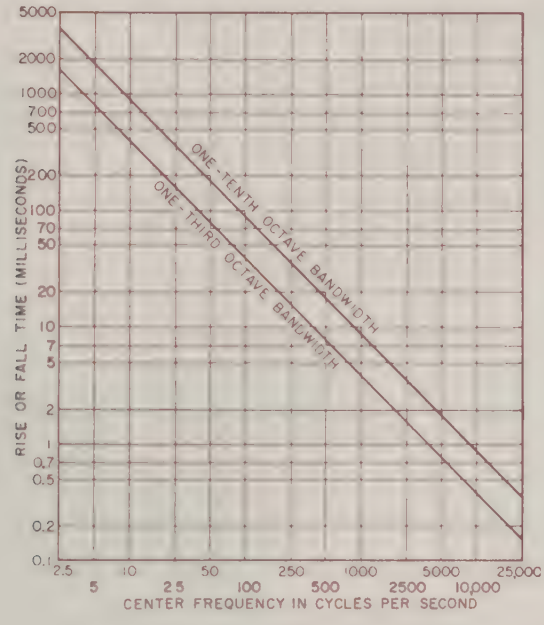

Figure 3-5. Rise and fall times for the filter.

3.5 OUTPUT AMPLIFIER SECTION.

In this section, the signal from the filter is amplified to a level sufficient to drive the meter circuit. This section also provides a one-volt output signal corresponding to a full-scale meter indication.

The meter detector circuit is push-pull driven to provide good linearity and stability. The detector characteristic has been called quasi-rms[2]. The conduction angle for sinusoidal excitation is chosen to give a detector output nearly rms, for various types of input signals, including noise and square waves.

Two amplifier stages and two attenuators permit a high signal-to-noise ratio, when little over-all gain is required. The attenuators are controlled by the BAND LEVEL knob.

To suit the wide frequency range of the analyzer, three detector-averaging times are used (refer to paragraph 2.17). These ensure that the user is not burdened with either a slow-acting meter for high-frequency measurements or a widely fluctuating meter for noise analyses at low frequencies.

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2 E. E. Gross, "Improved Performance Plus A New Look for the Sound-Level Meter," 32, 17, EXPERIMENTER, October, 1958.

3.6 CALIBRATION NETWORK.

To amplitude-calibrate the analyzer, the output is connected to the input through a diode limiter and a calibrated attenuator. A 1-kc, RC filter is also included when the BANDWIDTH switch is set to ALL PASS. The attenuation of this feedback network is the calibration reference; it is adjustable by means of a calibrated internal control (refer to paragraph 2.3). When the over-all gain of the instrument is adjusted to equal the attenuation of the calibration network, the system will oscillate, as indicated by the panel meter.

3.7 POWER SUPPLY.

The Type 1564-A Sound and Vibration Analyzer can be operated from its rechargeable nickel-cadmium battery or from a 115- (or 230-) volt, 50- to 60-cycle line. A simplified diagram of the power supply is given in Figure 3-6. For line operation, the transformer feeds a conventional bridge-rectifier and filter-capacitor circuit. The smoothed DC supplies both the circuits of the instrument and the battery. The latter serves to refilter the DC and receives a small charging current (about 5 ma for normal line voltage). Conventional series regulators, with zener diode references, supply 7, 12, and 15 volts for various sections of the instrument. The unregulated battery voltage supplies the final stage of the output amplifier.

The battery automatically supplies current for the instrument when the line is interrupted. The rectifier diodes prevent the current from flowing back through the transformer.

To charge the battery, the load is removed from the instrument and Switch S is closed (Figure 3-6).

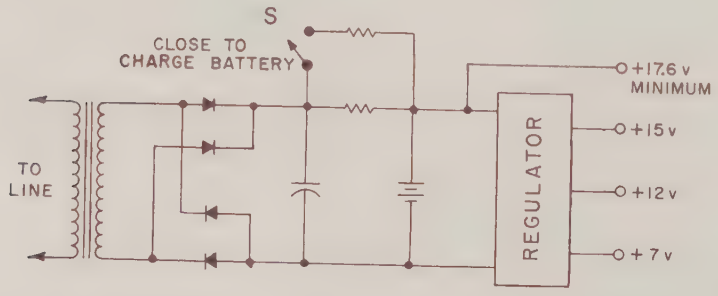


Figure 3-6. Elementary schematic diagram of power supply.

Section 4
SERVICE AND MAINTENANCE

4.1 GENERAL.

We warrant that each new instrument sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, district office, or authorized repair agency personnel, will be repaired, or, at our option replaced without charge, except for tubes or batteries that have given normal service.

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the type and serial numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest district office, requesting a Returned Material Tag. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

4.2 REMOVAL OF INSTRUMENT FROM CASE.

To remove the Type 1564-A from its Flip-Tilt case, turn the panel function switch to OFF and remove the four screws near the front panel, two through the top and two through the bottom of the case.

4.3 TRANSISTOR VOLTAGES.

Table 5 gives the normal voltage from the indicated transistor terminal to ground. Allow a deviation of 10 percent from these figures. Set the panel controls as follows:

BANDWIDTH switch - - - - - - - - - - - 1/10 OCTAVE
Function switch - - - - - - - - - - - - - FAST

FREQUENCY dial - - - - - - - - - - - - 10
FREQUENCY MULTIPLIER - - - - - - - 100
BAND LEVEL gray knob - - - - - - - - - maximum clockwise
BAND LEVEL knurled dial - - - - - - - - maximum clockwise

Measurements should be made with a vacuum-tube voltmeter with the battery fully charged (approximately 21 volts).

TABLE 5.
TRANSISTOR VOLTAGES

TRANSISTOR	TERMINAL	DC VOLTS TO GROUND	TRANSISTOR	TERMINAL	DC VOLTS TO GROUND
Q101	K	6.0	Q210	E	5.6
	A	11.9		C	11.9
Q102	E	12.0	Q211	E	12.0
	C	8.5		C	5.6
Q103	E	6.7	Q212	E	1.2
	C	11.9		C	5.6
Q104	E	12.0	Q301	E	0.9
	C	6.7		C	3.1
Q105	E	0.9	Q302	E	3.0
	C	3.0		C	6.4
Q106	E	2.9	Q303	E	1.4
	C	7.5		C	4.1
Q201	E	7.2	Q304	E	4.0
	C	11.9		C	13.6
Q202	E	12.0	Q305	E	13.5
	C	7.2		C	21.0
Q203	E	1.1	Q306	E	19.8
	C	7.2		C	12.0
Q204	E	7.4	Q307	E	20.0
	C	11.9		C	10.5
Q205	E	12.0	Q501	E	15.0
	C	7.8		C	21.0
Q206	E	6.4	Q502	E	12.0
	C	11.9		C	21.0
Q207	E	12.0	Q503	E	6.5
	C	6.4		C	12.1
Q208	E	5.9	Q504	E	6.5
	C	11.9		C	15.1
Q209	E	12.0	Q505	E	15.0
	C	6.2		C	21.0

4.4 INTERNAL NOISE.

Typical noise levels at the OUTPUT jack are given in Figure 4-1 for each setting of the BAND LEVEL control. The noise levels in decibels are referred to the output voltage corresponding to a full-scale meter indication (approximately db re 1 volt) for the 1/3-octave bandwidth with the INPUT terminals shorted. Levels will be approximately the same for the 1/10-octave bandwidth or with other source impedances.

NOTE

For a given voltage range, start with knurled dial and gray knob fully cw. If desired voltage range is 3 mV to .03 V, keep dial fully cw and adjust knob; for 0.1 V, keep both fully cw; for 0.3 V to 300 V, keep knob fully cw and adjust dial.

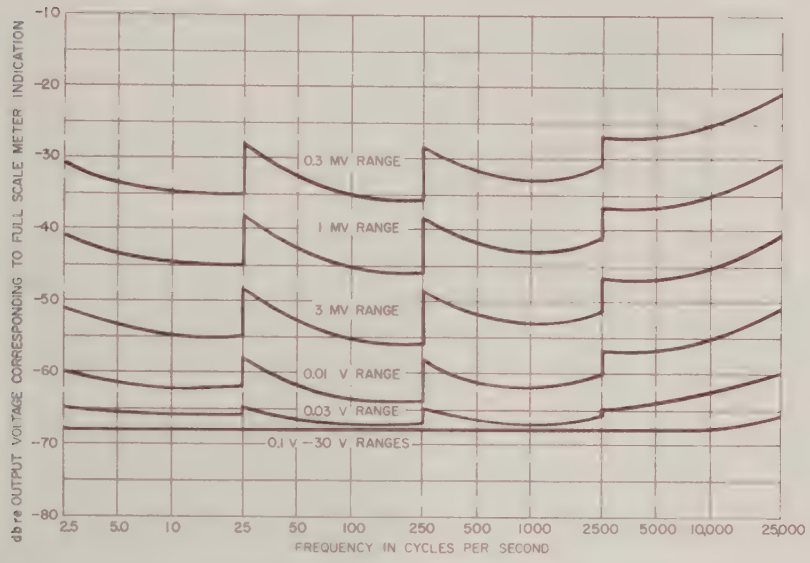


Figure 4-1. Typical noise levels at the OUTPUT of the analyzer.

4.5 SERVICEABILITY TEST.

Follow the procedure outlined below to determine that the gain of the analyzer is normal and that its filters are operating properly. An oscillator covering the range from 20 cps to 25 kc and an accurate voltmeter (to monitor the output level of the oscillator) are required.

a. ALL-PASS FREQUENCY RESPONSE CHECK. Connect the oscillator to the INPUT terminals of the analyzer and apply a level of 0.5 v at a frequency of 20 cps. Turn the function switch to SLOW, the BANDWIDTH switch to ALL PASS, the BAND LEVEL gray knob fully clockwise, and the BAND LEVEL knurled dial to $\frac{120}{1v}$. Adjust the CAL thumbset control so that the meter indicates +4 db. Change the oscillator frequency to 25 kc, keeping its level constant at 0.5 volt. The analyzer should now indicate between +1 and +3 db.

b. CHECK FOR UNIFORMITY OF PEAK RESPONSE WITH 1/10-OCTAVE BANDWIDTH. With the function switch and BAND LEVEL controls set as in a., above, turn the BANDWIDTH control to 1/10 OCTAVE, the FREQUENCY MULTIPLIER switch to 10, and the FREQUENCY control to 2.5. Adjust the oscillator frequency (at a 0.5-volt level) to give a peak indication on the analyzer meter, and note the reading. This peak indication should occur at a frequency of 25 cps ±2%. (If the oscillator is accurately calibrated, or if a suitable frequency-measuring instrument is available, the frequency of the analyzer can be checked.) Set the function switch to FAST and repeat the procedure, noting the peak amplitude at each of the following frequencies: 20 cps (FREQUENCY MULTIPLIER at 1), 100 cps, 250 cps,

1 kc, 2.5 kc, 10 kc, and 25 kc. Maintain the oscillator level at 0.5 v for each frequency. The difference between the maximum and minimum peak amplitudes, at frequencies up to 10 kc, should not exceed 2 db. Considering all frequencies, the variation should not exceed 3 db.

c. CHECK FOR UNIFORMITY OF CENTER-FREQUENCY RESPONSE WITH 1/3-OCTAVE BANDWIDTH. Set the BANDWIDTH switch at 1/3 OCTAVE and follow the procedure outlined in b.

d. CHECK FOR AMPLITUDE AGREEMENT AT CENTER FREQUENCY OF 1/3- AND 1/10-OCTAVE FILTER. At any frequency, adjust the oscillator for a peak meter indication, using the 1/10 OCTAVE BANDWIDTH switch position. Set the switch to 1/3 OCTAVE, maintain the 0.5-volt oscillator level, and note the change in meter indication. This change should not exceed 2 db at frequencies up to 10 kc; it should not exceed 3 db for frequencies above 10 kc.

4.6 FILTER REALIGNMENT.

The filter in the analyzer may require realignment when:

a. one or more tuning capacitors have been changed (mylar capacitors, one- or two-percent tolerance, selected by switches S201 and S202),

b. the tuning potentiometer has been changed,

c. transistor Q201, Q202, Q204, Q205, Q208, Q209, Q210, or Q211 has been replaced.

The serviceability test outlined in paragraph 4.5 should be used in any case, to determine whether or not realignment of the filter is necessary. The following instruments are required for this test:

An oscillator, covering the range from 20 cps to 25 kc, with some means of monitoring its level at approximately 0.5 v.

A sensitive ac voltmeter, for levels down to 30 mv having a uniform (±2%) frequency response from 25 cps to 25 kc.

A frequency meter or equivalent, to measure frequencies of 250 cps and 2.5 kc, with an accuracy of ±0.5%.

Use the procedure outlined below to realign the filter.

a. Remove the instrument from its cabinet. The etched-circuit board is hinged and must be swung out. To do this, remove the three screws near the bottom edge of the board and the screw just above the tuning potentiometer. Swing the board out until it is perpendicular to the panel. Set the analyzer on its right side (with switch S202 at the top).

b. Set the following alignment potentiometers near the center of their ranges: R202, R209, R214, R215, R216, R217, R228, R234, R235, R236, R237, and R239.

Set the panel controls of the analyzer as follows:

BAND LEVEL gray knob	fully clockwise
BAND LEVEL knurled dial	1 v (12 o'clock)

FREQUENCY switch	2.5
FREQUENCY MULTIPLIER switch	100
BANDWIDTH switch	1/10 OCTAVE

Both BAND LEVEL controls should be left in the above respective positions for steps b through g.

The BANDWIDTH switch should be left at 1/10 OCTAVE for steps b through n.

Remove the two screws that hold the cover over the FREQUENCY dial (the two nearest the lower edge of the panel).

c. Connect the sensitive ac voltmeter to terminal 308R on switch S202. Be sure the terminal is not shorted to ground or to any other terminal, as this may result in damage to transistor Q205 or Q502. Connect the oscillator to the INPUT jack and set it for a frequency of 250 cps ±0.5% at an amplitude of 0.5 v. Set the function switch to FAST and adjust the CAL control for an indication of about 300 mv on the sensitive ac voltmeter. Turn the FREQUENCY dial of the analyzer until a peak indication on the voltmeter is obtained. This peak should occur at 250 cps ±0.5% as indicated by the FREQUENCY dial. If it does not, loosen the two setscrews that secure the dial to the shaft. Set the dial so that it indicates exactly 250 cps and tighten both setscrews.

d. Maintain the 0.5-volt oscillator level for all the adjustments in steps d through g.

With the oscillator set at 2.5 kc, adjust the CAL control on the analyzer for a voltmeter indication of 30 mv. Then adjust the frequency of the oscillator to give a peak indication on the voltmeter at 250 cps. Using potentiometer R216, set this peak level to 270 mv.

e. Set the FREQUENCY dial to 25, and adjust the oscillator frequency for a peak indication on the voltmeter, which will occur near 2.5 kc. Then adjust potentiometers R202 and R209 to obtain a peak voltmeter indication of 270 mv at 2.5 kc, as indicated by the frequency meter. A clockwise rotation of R202 decreases both the amplitude and the frequency of the peak. A clockwise rotation of R209 increases the peak amplitude and decreases the peak frequency.

f. Set the FREQUENCY dial to 2.5 and the FREQUENCY MULTIPLIER to 1000. The peak amplitude should occur at about 2.5 kc. Adjust potentiometer R217 for a voltmeter indication of 270 mv. Repeat this procedure at 25 cps (with the FREQUENCY MULTIPLIER set to 10). Use potentiometer R215 to again obtain the voltmeter indication of 270 mv.

g. Set the FREQUENCY dial to 25, the FREQUENCY MULTIPLIER to 1, and adjust potentiometer R214 for a peak amplitude of 270 mv.

h. Turn the function switch to OFF and unsolder the orange-gray shielded lead connected to terminal 308R of switch S202. Select an electrolytic or paper capacitor with a value of 1 μf or higher and a voltage rating of at least 15 volts. Solder the positive terminal of this capacitor to terminal 308R. Connect the oscillator to the analyzer through the capacitor

(with the low oscillator terminal connected to the chassis) and adjust the oscillator level to about 0.4 volt.

i. Set the FREQUENCY dial to 2.5, the FREQUENCY MULTIPLIER to 100, the function switch to SLOW and the BAND LEVEL knob to $\frac{100}{.1v}$. The indicator on the BAND LEVEL knurled dial should remain at 12 o'clock. With the frequency of the oscillator at 25 cps, adjust its level for a full-scale indication on the analyzer meter and note this level.

Change the BAND LEVEL knob setting to $\frac{120}{1v}$, the function switch to FAST, and adjust the frequency of the oscillator for a peak indication on the analyzer. Set the oscillator amplitude to the level noted above and maintain this level for the remainder of the procedure. Adjust potentiometer R236 for an indication of 9 on the meter (10-volt scale).

j. Set the FREQUENCY MULTIPLIER to 10, the function switch to SLOW, and adjust the peak amplitude at 25 cps for an indication of 9, using R235. Change the function switch to FAST and the FREQUENCY dial to 25. Adjust R228 and R329 to obtain a peak meter indication of 9 at a frequency of 250 cps, as indicated by the frequency meter. A clockwise rotation of R228 increases the amplitude and decreases the frequency; a clockwise rotation of R239 decreases both the amplitude and the frequency of the peak.

k. Set the FREQUENCY MULTIPLIER switch to 1 and adjust potentiometer R234 for a peak amplitude indication of 9.

l. Set the FREQUENCY dial to 2.5 and the FREQUENCY MULTIPLIER to 1000. Adjust potentiometer R237 for a peak amplitude indication of 9.

m. Turn the function switch to OFF. Disconnect the oscillator and the capacitor connected to terminal 308R of switch S202, and resolder the orange-gray shielded lead.

n. Connect the oscillator to the INPUT terminals of the analyzer and set the input level to 0.5 v at 1 kc. Turn the function switch to FAST, the FREQUENCY MULTIPLIER to 100, and tune the FREQUENCY dial to obtain a peak indication on the meter. Note the level.

Set the BANDWIDTH switch to 1/3 OCTAVE. The change in level must not exceed 2 db. Note this level.

Change the BANDWIDTH switch to ALL PASS and use potentiometer R125 to adjust the ALL PASS level so that it is midway between the 1/10- and 1/3-octave levels.

o. Check the analyzer according to the procedure given in paragraph 4.5. If an oscillator with a range to 2.5 cps is available, the four checks in paragraph 4.5 can be extended to the lower decade. Both the 1/3-octave and the 1/10-octave peak levels should be uniform ±1 db down to 5 cps and uniform ±1.5 db down to 2.5 cps. The center-frequency amplitudes for the 1/3- and the 1/10-octave bandwidths should agree within 2 db down to 2.5 cps. The all-pass amplitude should be down 1, ±1 db (referred to the level at 1 kc) at 2.5 cps, when the function switch is at SLOW.

4.7 KNOB REMOVAL.

To remove the knob on a front-panel control, either to replace one that has been damaged or to replace the associated control, proceed as follows:

a. Grasp the knob firmly with the fingers, close into the panel (or the indicator dial, if applicable) and pull the knob straight, away from the panel.

CAUTION

Do not pull on the dial to remove a dial/knob assembly. Always remove the knob first.

b. Observe the position of the setscrew in the bushing, with respect to any panel markings (or at the full CCW position of a continuous control).

c. Release the setscrew with an Allen wrench and pull the bushing off the shaft.

d. Remove and retain the black nylon thrust washer, behind the dial/knob assembly, as appropriate.

NOTE

To separate the bushing from the knob, if for any reason they should be combined off the instrument, drive a machine tap a turn or two into the bushing to provide sufficient grip for easy separation.

4.8 KNOB INSTALLATION.

To install a Snap-on knob assembly on the control shaft:

a. Place the black nylon thrust washer over the control shaft, if appropriate.

b. Mount the bushing on the shaft, using a small slotted piece of wrapping paper as a shim for adequate panel clearance.

c. Orient the setscrew on the bushing with respect to the panel-marking index and lock the setscrew with an Allen wrench.

NOTE

Make sure that the end of the shaft does not protrude through the bushing or the knob won't seat properly.

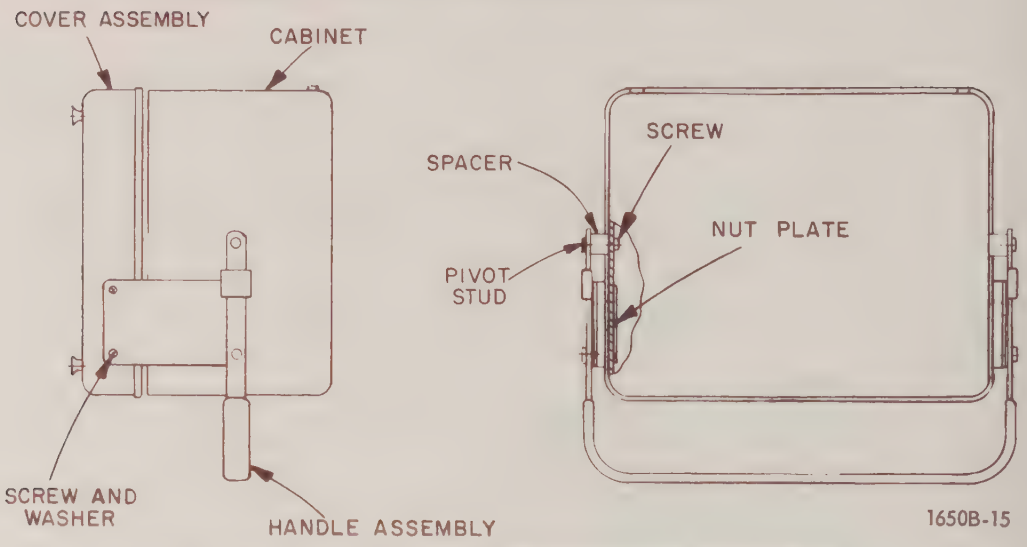
d. Place the knob on the bushing with the retention spring opposite the setscrew.

e. Push the knob in until it bottoms and pull it slightly to check that the retention spring is seated in the groove in the bushing.

NOTE

If the retention spring in the knob comes loose, reinstall it in the interior notch with the small slit in the outer wall.

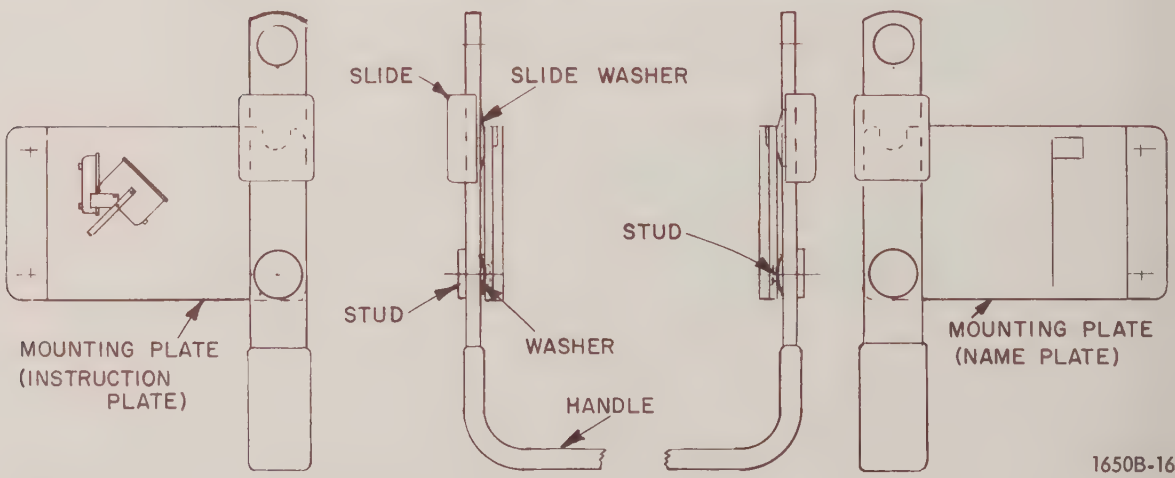
COMPONENT PARTS OF THE FLIP-TILT CABINET



Name	GR Part No.	Name	GR Part No.
Cabinet	1564-3200	Cover Assembly	4170-0282
Spacer	4170-0700	Nut Plate	4170-1375
Pivot Stud	4170-1000	Screw	7080-1000
Screw*	7090-4031	Washer	8040-2400
Handle Assembly	1564-2200		

*Tighten 1/4-28 screws to 45-55 in. lbs torque.
**Bend mounting plate to give 1/32 to 1/16 spacing, both sides.

Name	GR Part No.	Name	GR Part No.
Mounting Plate** (Instruction Plate)	7860-9812	Mounting Plate (Name Plate)	7864-8190
Stud	4170-1100	Washer	8140-0105
Slide	4170-1270	Slide Washer	4170-7030
Handle	5360-0980		



FEDERAL MANUFACTURERS CODE

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) as supplemented through June, 1967.

Code	Manufacturers Name and Address
00192	Jones Mfg. Co., Chicago, Illinois
00194	Walsco Electronics Corp., Los Angeles, Calif.
00656	Aerovox Corp., New Bedford, Mass.
01009	Alden Products Co., Brockton, Mass.
01121	Allen-Bradley, Co., Milwaukee, Wisc.
01295	Texas Instruments, Inc., Dallas, Texas
02114	Ferroxcube Corp. of America, Saugerties, N. Y. 12477
02606	Fenwal Lab. Inc., Morton Grove, Ill.
02660	Amphenol Electronics Corp., Broadview, Ill.
02768	Fastex Division of Ill. Tool Works, Des Plaines, Ill. 60016
03508	G. E. Semiconductor Products Dept., Syracuse, N. Y. 13201
03636	Grayburne, Yonkers, N. Y. 10701
03888	Pyrofilm Resistor Co., Cedar Knolls, N. J.
03911	Clairex Corp., New York, N. Y. 10001
04009	Arrow, Hart and Hegeman Electric Co., Hartford, Conn. 06106
04713	Motorola Semi-Conduct Product, Phoenix, Ariz. 85008
05170	Engineered Electronics Co., Inc., Santa Ana, Calif. 92702
05624	Barber-Colman Co., Rockford, Ill. 61101
05820	Wakefield Eng., Inc., Wakefield, Mass. 01880
07127	Eagle Signal Div. of E. W. Bliss Co., Baraboo, Wisc.
07261	Avnet Corp., Culver City, Calif. 90230
07263	Fairchild Camera and Instrument Corp., Mountain View, Calif.
07387	Birtcher Corp., No. Los Angeles, Calif.
07595	American Semiconductor Corp., Arlington Heights, Ill. 60004
07828	Bodine Corp., Bridgeport, Conn. 06605
07829	Bodine Electric Co., Chicago, Ill. 60618
07910	Continental Device Corp., Hawthorne, Calif.
07983	State Labs Inc., N. Y., N. Y. 10003
07999	Amphenol Corp., Borg Inst. Div., Delavan, Wisc. 53115
08730	Vemaline Prod. Co., Franklin Lakes, N. J.
09213	General Electric Semiconductor, Buffalo, N. Y.
09823	Burgess Battery Co., Freeport, Ill.
09922	Burndy Corp., Norwalk, Conn. 06852
11599	Chandler Evans Corp., W. Hartford, Conn.
12498	Teledyn Inc., Crystalonics Div., Cambridge, Mass. 02140
12672	RCA Commercial Receiving Tube and Semiconductor Div., Woodridge, N.J.
12697	Clarostat Mfg. Co. Inc., Dover, N. H. 03820
12954	Dickson Electronics Corp., Scottsdale, Ariz.
13327	Solitron Devices, Tappan, N. Y. 10983
14433	ITT Semiconductors, W. Palm Beach, Florida
14655	Cornell Dubilier Electric Co., Newark N. J.
14674	Corning Glass Works, Corning, N. Y.
14936	General Instrument Corp., Hicksville, N. Y.
15238	ITT, Semiconductor Div. of Int. T. and T, Lawrence, Mass.
15605	Cutler-Hammer Inc., Milwaukee, Wisc. 53233
16037	Spruce Pine Mica Co., Spruce Pine, N. C.
19701	Electra Mfg. Co., Independence, Kansas 67301
21335	Fafnir Bearing Co., New Briton, Conn.
24446	G. E. Schenectady, N. Y. 12305
24454	G. E., Electronic Comp., Syracuse, N. Y.
24455	G. E. (Lamp Div), Nela Park, Cleveland, Ohio
24655	General Radio Co., W. Concord, Mass 01781
26806	American Zettler Inc., Costa Mesa, Calif.
28520	Hayman Mfg. Co., Kenilworth, N. J.
28959	Hoffman Electronics Corp., El Monte, Calif.
30874	International Business Machines, Armonk, N.Y.
32001	Jensen Mfg. Co., Chicago, Ill. 60638
35929	Constanta Co. of Canada Limited, Montreal 19, Quebec
37942	P. R. Mallory and Co. Inc., Indianapolis, Ind.
38443	Marlin-Rockwell Corp., Jamestown, N. Y.
40931	Honeywell Inc., Minneapolis, Minn. 55408
42190	Muter Co., Chicago, Ill. 60638
42498	National Co. Inc., Melrose, Mass. 02176
43991	Norma-Hoffman Bearings Corp., Stanford, Conn. 06904
49671	RCA, New York, N. Y.
49956	Raytheon Mfg. Co., Waltham, Mass. 02154
53021	Sangamo Electric Co., Springfield, Ill. 62705
54294	Shallcross Mfg. Co., Selma, N. C.
54715	Shure Brothers, Inc., Evanston, Ill.
56289	Sprague Electric Co., N. Adams, Mass.
59730	Thomas and Betts Co., Elizabeth, N. J. 07207
59875	TRW Inc. (Accessories Div), Cleveland, Ohio
60399	Torrington Mfg. Co., Torrington, Conn.
61637	Union Carbide Corp., New York, N. Y. 10017
61864	United-Carr Fastener Corp., Boston, Mass.
63060	Victoreen Instrument Co., Inc., Cleveland, Ohio
63743	Ward Leonard Electric Co., Mt. Vernon, N. Y.
65083	Westinghouse (Lamp Div), Bloomfield, N. J.
65092	Weston Instruments, Weston-Newark, Newark, N. J.
70485	Atlantic-India Rubber Works, Inc., Chicago, Ill. 60607
70563	Amperite Co., Union City, N. J. 07087
70903	Belden Mfg. Co., Chicago, Ill. 60644
71126	Bronson, Homer D., Co., Beacon Falls, Conn.
71294	Canfield, H. O. Co., Clifton Forge, Va. 24422
71400	Bussman Mfg. Div. of McGraw Edison Co., St. Louis, Mo.
71590	Centralab, Inc., Milwaukee, Wisc. 53212
71666	Continental Carbon Co., Inc., New York, N. Y.
71707	Coto Coil Co. Inc., Providence, R. I.
71744	Chicago Miniature Lamp Works, Chicago, Ill.
71785	Cinch Mfg. Co. and Howard B. Jones Div., Chicago, Ill. 60624
71823	Darnell Corp., Ltd., Downey, Calif. 90241
72136	Electro Motive Mfg. Co., Willmington, Conn.
72259	Nytronics Inc., Berkeley Heights, N. J. 07922
72619	Dialight Co., Brooklyn, N. Y. 11237
72699	General Instrument Corp., Capacitor Div., Newark, N. J. 07104
72765	Drake Mfg. Co., Chicago, Ill. 60656
72825	Hugh H. Eby, Inc., Philadelphia, Penn. 19144
72962	Elastic Stop Nut Corp., Union, N. J. 07083
72982	Erie Technological Products Inc., Erie, Penn.
73445	Amperex Electronics Co., Hicksville, N. Y.
73559	Carling Electric Co., W. Hartford, Conn.
73690	Elco Resistor Co., New York, N. Y.
73899	J. F. D. Electronics Corp., Brooklyn, N. Y.
74193	Heinemann Electric Co., Trenton, N. J.
74861	Industrial Condenser Corp., Chicago, Ill.
74970	E. F. Johnson Co., Waseca, Minn. 56093
75042	IRC Inc., Philadelphia, Penn. 19108
75382	Kulka Electric Corp., Mt. Vernon, N. Y.
75608	Linden and Co., Providence, R. I.
75915	Littelfuse, Inc., Des Plaines, Ill. 60016
76005	Lord Mfg. Co., Erie, Penn. 16512
76487	James Millen Mfg. Co., Malden, Mass. 02148
76545	Mueller Electric Co., Cleveland, Ohio 44114
76684	National Tube Co., Pittsburg, Penn.
76854	Oak Mfg. Co., Crystal Lake, Ill.
77147	Patton MacGuyer Co., Providence, R. I.
77166	Pass-Seymour, Syracuse, N. Y.
77263	Pierce Roberts Rubber Co., Trenton, N. J.
77339	Positive Lockwasher Co., Newark, N. J.
77542	Ray-O-Vac Co., Madison, Wisc.
77630	TRW, Electronic Component Div., Camden, N. J. 08103
77638	General Instruments Corp., Brooklyn, N. Y.
78189	Shakeproof Div. of Ill. Tool Works, Elgin, Ill. 60120
78277	Sigma Instruments Inc., S. Braintree, Mass.
78488	Stackpole Carbon Co., St. Marys, Penn.
78553	Tinnerman Products, Inc., Cleveland, Ohio
79089	RCA, Commercial Receiving Tube and Semiconductor Div., Harrison, N. J.
79725	Wiremold Co., Hartford, Conn. 06110
79963	Zierick Mfg. Co., New Rochelle, N. Y.
80030	Prestole Fastener Div. Bishop and Babcock Corp., Toledo, Ohio
80048	Vickers Inc. Electric Prod. Div., St. Louis, Mo.
80131	Electronic Industries Assoc., Washington, D.C.
80211	Motorola Inc., Franklin Park, Ill. 60131
80258	Standard Oil Co., Lafeyette, Ind.
80294	Bourns Inc., Riverside, Calif. 92506
80431	Air Filter Corp., Milwaukee, Wisc. 53218
80583	Hammarlund Co. Inc., New York, N. Y.
80740	Beckman Instruments, Inc., Fullerton, Calif.
81073	Grayhill Inc., LaGrange, Ill. 60525
81143	Isolantite Mfg. Corp., Stirling, N. J. 07980
81349	Military Specifications
81350	Joint Army-Navy Specifications
81751	Columbus Electronics Corp., Yonkers, N. Y.
81831	Filton Co., Flushing, L. I., N. Y
81860	Barry Controls Div. of Barry Wright Corp., Watertown, Mass.
82219	Sylvania Electric Products, Inc., (Electronic Tube Div.), Emporium, Penn.
82273	Indiana Pattern and Model Works, LaPort, Ind.
82389	Switchcraft Inc., Chicago, Ill. 60630
82647	Metals and Controls Inc., Attleboro, Mass.
82807	Milwaukee Resistor Co., Milwaukee, Wisc.
83058	Carr Fastener Co., Cambridge, Mass.
83186	Victory Engineering Corp (IVECO), Springfield, N. J. 07081
83361	Bearing Specialty Co., San Francisco, Calif.
83587	Solar Electric Corp., Warren, Penn.
83740	Union Carbide Corp., New York, N. Y. 10017
84411	TRW Capacitor Div., Ogallala, Nebr.
84835	Lehigh Metal Products Corp., Cambridge, Mass. 02140
84971	TA Mfg. Corp., Los Angeles, Calif.
86577	Precision Metal Products of Malden Inc., Stoneham, Mass. 02180
86684	RCA (Electrical Component and Devices) Harrison, N. J.
88140	Cutler-Hammer Inc., Lincoln, Ill.
88219	Gould Nat. Batteries Inc., Trenton, N. J.
88419	Cornell Dubilier Electric Corp., Fuquay-Varina, N. C.
88627	K and G Mfg. Co., New York, N. Y.
89482	Holtzer Cabot Corp., Boston, Mass.
89665	United Transformer Co., Chicago, Ill.
90201	Mallory Capacitor Co., Indianapolis, Ind.
90750	Westinghouse Electric Corp., Boston, Mass.
90952	Hardware Products Co., Reading, Penn. 19602
91032	Continental Wire Corp., York, Penn. 17405
91146	ITT Cannon Electric Inc., Salem, Mass.
91293	Johanson Mfg. Co., Boonton, N. J. 07005
91598	Chandler Co., Wethersfield, Conn. 06109
91637	Dale Electronics Inc., Columbus, Nebr.
91662	Elco Corp., Willow Grove, Penn.
91719	General Instruments, Inc., Dallas, Texas
91929	Honeywell Inc., Freeport, Ill.
92519	Electra Insulation Corp., Woodside, Long Island, N. Y.
92678	Edgerton, Germeshausen and Grier, Boston, Mass.
93332	Sylvania Electric Products, Inc., Woburn, Mass.
93916	Cramer Products Co., New York, N. Y. 10013
94144	Raytheon Co. Components Div., Quincy, Mass.
94154	Tung Sol Electric Inc., Newark, N. J.
95076	Garde Mfg. Co., Cumberland, R. I.
95146	Alco Electronics Mfg. Co., Lawrence, Mass.
95238	Continental Connector Corp., Woodside, N. Y.
95275	Vitramon, Inc., Bridgeport, Conn.
95354	Methode Mfg. Co., Chicago, Ill.
95412	General Electric Co., Schenectady, N. Y.
95794	Ansconda American Brass Co., Torrington, Conn.
96095	Hi-Q Div. of Aerovox Corp., Orlean, N. Y.
96214	Texas Instruments Inc., Dallas, Texas 75209
96256	Thordarson-Meissner Div. of McGuire, Mt. Carmel, Ill.
96341	Microwave Associates Inc., Burlington, Mass.
96906	Military Standards
97966	CBS Electronics Div. of Columbia Broadcasting Systems, Danvers, Mass.
98291	Sealectro Corp., Mamaroneck, N. Y. 10544
98821	North Hills Electronics Inc., Glen Cove, N. Y.
99180	Transitron Electronics Corp., Melrose, Mass.
99378	Atlee Corp., Winchester, Mass. 01890
99800	Delevan Electronics Corp., E. Aurora, N. Y.

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PARTS LIST

REF. NO.	DESCRIPTION	PART NO.	FMC	MFG. PART NO.	FED. STOCK NO.
RESISTORS					
R101	FILM, 22.6 MΩ ±1% 1 w	6189-5226	03888	PT1000	
R102	FILM, 255 KΩ ±1% 1/8 w	6250-3255	75042	CEA, 255 KΩ ±1%	5905-805-2117
R103	FILM, 2.55 MΩ ±1% 1/2 w	6450-4255	75042	CEC, 2.55 MΩ ±1%	
R104	COMPOSITION, 470 KΩ ±5% 1/2 w	6100-4475	01121	RC20GF474J	5905-279-2515
R105	COMPOSITION, 300 KΩ ±5% 1/2 w	6100-4305	01121	RC20GF304J	5905-185-6859
R106	COMPOSITION, 47 MΩ ±5% 1/2 w	6100-6105	01121	RC20GF106J	5905-279-1865
R107	COMPOSITION, 12 KΩ ±10%	6099-3129	75042	BTS, 12 KΩ ±10%	
R108	POTENTIOMETER, COMPOSITION, 100 KΩ ±20%	6040-1000	01121	FWC, 100 KΩ ±20%	5905-958-7949
R109	COMPOSITION, 47 MΩ ±5% 1/2 w	6100-6475	01121	RC20GF476J	5905-794-3893
R110	COMPOSITION, 10 KΩ ±5% 1/2 w	6100-3105	01121	RC20GF103J	5905-185-8510
R111	COMPOSITION, 6.2 KΩ ±5% 1/2 w	6100-2625	01121	RC20GF622J	5905-279-2673
R112	COMPOSITION, 100 KΩ ±5% 1/2 w	6100-4105	01121	RC20GF104J	5905-195-6761
R113	POTENTIOMETER, 100 KΩ ±10%	6010-1700	01121	Jμ, 100 KΩ +10%	5905-797-1054
R114	FILM, 22.6 KΩ ±1% 1/8 w	6250-2226	75042	CEA, 22.6 KΩ ±1%	5905-683-5747
R115	FILM, 15.4 KΩ ±1% 1/8 w	6250-2154	75042	CEA, 15.4 KΩ ±1%	5905-556-3775
R116	FILM, 71.5 KΩ ±1% 1/8 w	6250-2715	75042	CEA, 71.5 KΩ ±1%	
R117	FILM, 61.9 KΩ ±1% 1/8 w	6250-2619	75042	CEA, 61.9 KΩ ±1%	5905-726-4953
R118	COMPOSITION, 15 KΩ ±5% 1/2 w	6100-3155	01121	RC20GF153J	5905-279-2616
R119	COMPOSITION, 30 KΩ ±5% 1/2 w	6100-3305	01121	RC20GF303J	5905-192-3978
R120	COMPOSITION, 10 KΩ ±5% 1/2 w	6100-3105	01121	RC20GF103J	5905-185-8510
R121	COMPOSITION, 120 KΩ ±5% 1/2 w	6100-4125	01121	RC20GF124J	5905-192-3981
R122	COMPOSITION, 20 KΩ ±5% 1/2 w	6100-3205	01121	RC20GF203J	5905-192-0649
R123	COMPOSITION, 10 KΩ ±5% 1/2 w	6100-3105	01121	RC20GF103J	5905-185-8510
R124	COMPOSITION, 36 KΩ ±5% 1/2 w	6100-3365	01121	RC20GF363J	5905-249-4256
R125	POTENTIOMETER, COMPOSITION, 50 KΩ ±20%	6040-0900	01121	FWC, 50 KΩ ±20%	5905-072-7724
R126	COMPOSITION, 91 KΩ ±5% 1/2 w	6100-3915	01121	RC20GF913J	5905-254-7100
R127	COMPOSITION, 18 KΩ ±5% 1/2 w	6100-3185	01121	RC20GF183J	5905-279-3500
R128	COMPOSITION, 8.2 KΩ ±5% 1/2 w	6100-2825	01121	RC20GF822J	5905-299-1971
R129	COMPOSITION, 300 KΩ ±5% 1/2 w	6100-4305	01121	RC20GF304J	5905-185-6859
R130	COMPOSITION, 100 KΩ ±5% 1/4 w	6099-4105	75042	BTS, 100 KΩ ±5%	
R201 A	POTENTIOMETER, 30.7 KΩ	0973-4300	24655	0973-4300	
R201 B	POTENTIOMETER, 30.7 KΩ	0973-4300	24655	0973-4300	
R201 C	POTENTIOMETER, 30.7 KΩ	0973-4300	24655	0973-4300	
R201 D	POTENTIOMETER, 30.7 KΩ	0973-4300	24655	0973-4300	
R202	POTENTIOMETER, COMPOSITION, 500 Ω ±20%	6040-0300	01121	FWC, 500 Ω ±20%	5905-072-7795
R203	PRECISION, 2.74 KΩ ±1% .3 w	6730-1274	80131	A22, 2.74 KΩ ±1%	
R204	COMPOSITION, 30 KΩ ±5% 1/2 w	6100-3305	01121	RC20GF303J	5905-192-3978
R205	COMPOSITION, 91 KΩ ±5% 1/2 w	6100-3915	01121	RC20GF913J	5905-254-7100
R206	COMPOSITION, 13 KΩ ±5% 1/2 w	6100-3135	01121	RC20GF133J	5905-279-2669
R207	COMPOSITION, 1 KΩ ±5% 1/2 w	6100-2105	01121	RC20GF102J	5905-195-6806
R209	POTENTIOMETER, COMPOSITION, 500 Ω 20%	6040-0300	01121	FWC, 500 Ω ±20%	5905-072-7795
R210	PRECISION, 2.74 KΩ ±1% .3 w	6730-1274	80131	A22, 2.74 KΩ ±1%	
R211	COMPOSITION, 15 KΩ ±5% 1/2 w	6100-3155	01121	RC20GF153J	5905-279-2616
R212	PRECISION, 10 KΩ ±1% .3 w	6730-2100	80131	A22, 10 KΩ ±1%	
R213	COMPOSITION, 30 KΩ ±5% 1/2 w	6100-3305	01121	RC20GF303J	5905-192-3978
R214	POTENTIOMETER, COMPOSITION, 250 Ω ±20%	6040-0200	01121	FWC, 250 Ω ±20%	5905-072-7723
R215	POTENTIOMETER, COMPOSITION, 250 Ω ±20%	6040-0200	01121	FWC, 250 Ω ±20%	
R216	POTENTIOMETER, COMPOSITION, 250 Ω ±20%	6040-0200	01121	FWC, 250Ω ±20%	5905-072-7723
R217	POTENTIOMETER, COMPOSITION, 500 Ω ±20%	6040-0300	01121	FWC, 500Ω ±20%	5905-072-7795
R218	PRECISION, 432 Ω ±1% .3 w	6730-0432	80131	A22, 432Ω ±1%	
R219	FILM, 1.40 KΩ ±1% 1/8 w	6250-1140	75042	CEA, 1.40 KΩ ±1%	
R220	COMPOSITION, 4.7 KΩ ±5% 1/2 w	6100-2475	01121	RC20GF472J	5905-279-3504
R221	FILM, 90.9 KΩ ±1% 1/8 w	6250-2909	75042	CEA, 90.9 KΩ ±1%	5905-725-2120
R222	FILM, 9.53 KΩ ±1% 1/8 w	6250-1953	75042	CEA, 9.53 KΩ ±1%	5905-755-2759
R223	FILM, 20.5 KΩ ±1% 1/8 w	6250-2205	75042	CEA, 20.5 KΩ ±1%	5905-819-1262
R224	COMPOSITION, 15 KΩ ±5% 1/2 w	6100-3155	01121	RC20GF153J	5905-279-2616
R225	COMPOSITION, 30 KΩ ±5% 1/2 w	6100-3305	01121	RC20GF303J	5905-192-3978
R226	COMPOSITION, 10 KΩ ±5% 1/2 w	6100-3105	01121	RC20GF103J	5905-185-8510
R227	COMPOSITION, 8.2 MΩ ±5% 1/2 w	6100-5825	01121	RC20GF825J	5905-279-1888
R228	POTENTIOMETER, COMPOSITION, 500 Ω ±20%	6040-0300	01121	FWC, 500Ω ±20%	5905-072-7795
R229	PRECISION, 2.74 KΩ ±1% .3 w	6730-1274	80131	A22, 2.74 KΩ ±1%	
R230	COMPOSITION, 4.7 KΩ ±5% 1/2 w	6100-2475	01121	RC20GF472J	5905-279-3504
R231	COMPOSITION, 30 KΩ ±5% 1/2 w	6100-3305	01121	RC20GF303J	5905-192-3978
R232	PRECISION, 10 KΩ ±1% .3 w	6730-2100	80131	A22, 10 KΩ ±1%	
R233	PRECISION, 432 Ω ±1% .3 w	6730-0432	80131	A22, 432 Ω ±1%	
R234	POTENTIOMETER, COMPOSITION, 250 Ω ±20%	6040-0200	01121	FWC, 250 Ω ±20%	5905-072-7723

PARTS LIST (Cont.)

REF. NO.	DESCRIPTION	PART NO.	FMC MFG. PART NO.	FED. STOCK NO.
RESISTORS,				
R235	POTENTIOMETER, COMPOSITION, 250 Ω ±20%	6040-0200	01121 FWC, 250 Ω ±20%	5905-072-7723
R236	POTENTIOMETER, COMPOSITION, 250 Ω ±20%	6040-0200	01121 FWC, 250 Ω ±20%	5905-072-7723
R237	POTENTIOMETER, COMPOSITION, 500 Ω ±20%	6040-0300	01121 FWC, 500 Ω ±20%	5905-072-7795
R239	POTENTIOMETER, COMPOSITION, 500 Ω ±20%	6040-0300	01121 FWC, 500 Ω ±20%	5905-072-7795
R240	PRECISION, 2.74 KΩ ±1% .3 w	6730-1274	80131 A22, 2.74 KΩ ±1%	
R241	COMPOSITION, 30 KΩ ±5% 1/2 w	6100-3305	01121 RC20GF303J	5905-192-3978
R242	COMPOSITION, 91 KΩ ±5% 1/2 w	6100-3915	01121 RC20GF913J	5905-254-7100
R243	COMPOSITION, 13 KΩ ±5% 1/2 w	6100-3135	01121 RC20GF133J	5905-279-2669
R244	COMPOSITION, 1 KΩ ±5% 1/2 w	6100-2105	01121 RC20GF102J	5905-195-6806
R245	COMPOSITION, 100 KΩ ±5% 1/2 w	6100-4105	01121 RC20GF104J	5905-195-6761
R246	COMPOSITION, 1 KΩ ±5% 1/2 w	6100-2105	01121 RC20GF102J	5905-195-6806
R301	COMPOSITION, 160 KΩ ±5% 1/2 w	6100-4165	01121 RC20GF164J	5905-279-1871
R302	FILM, 3.83 KΩ ±1% 1/8 w	6250-1383	75042 CEA, 3.83 KΩ ±1%	5905-827-3333
R303	FILM, 10 KΩ ±1% 1/8 w	6250-2100	75042 CEA, 10 KΩ ±1%	5905-883-4847
R304	FILM, 20.5 KΩ ±1% 1/8 w	6250-2205	75042 CEA, 20.5 KΩ ±1%	5905-819-1262
R305	COMPOSITION, 120 KΩ ±5% 1/2 w	6100-4125	01121 RC20GF124J	5905-192-3981
R306	COMPOSITION, 10 KΩ ±5% 1/2 w	6100-3105	01121 RC20GF103J	5905-185-8510
R307	FILM, 60.4 KΩ ±1% 1/8 w	6250-2604	75042 CEA, 10 KΩ ±5%	5905-755-0675
R308	FILM, 60.4 KΩ ±1% 1/8 w	6250-2604	75042 CEA, 10 KΩ ±5%	5905-755-0675
R309	COMPOSITION, 330 KΩ ±5% 1/2 w	6100-4335	01121 RC20GF334J	5905-279-2519
R310	COMPOSITION, 20 KΩ ±5% 1/2 w	6100-3205	01121 RC20GF203J	5905-192-0649
R311	COMPOSITION, 8.2 KΩ ±5% 1/2 w	6100-2825	01121 RC20GF822J	5905-299-1971
R312	COMPOSITION, 100 KΩ ±5% 1/2 w	6100-4105	01121 RC20GF104J	5905-195-6761
R313	FILM, 20.5 KΩ ±1% 1/8 w	6250-2205	75042 CEA, 20.5 KΩ ±1%	5905-819-1262
R314	FILM, 10 KΩ ±1% 1/8 w	6250-2100	75042 CEA, 10 KΩ ±1%	5905-883-4847
R315	FILM, 3.83 KΩ ±1% 1/8 w	6250-1383	75042 CEA, 3.83 KΩ ±1%	5905-827-3333
R316	COMPOSITION, 62 KΩ ±5% 1/2 w	6100-3625	01121 RC20GF623J	5905-249-3656
R317	FILM, 60.4 KΩ ±1% 1/8 w	6250-2604	75042 CEA, 60.4 KΩ ±1%	5905-755-0675
R318	COMPOSITION, 5.1 KΩ ±5% 1/2 w	6100-2515	01121 RC20GF512J	5905-279-2019
R319	FILM, 60.4 KΩ ±1% 1/8 w	6250-2604	75042 CEA, 60.4 KΩ ±1%	5905-755-0675
R320	COMPOSITION, 6.8 KΩ ±5% 1/2 w	6100-2685	01121 RC20GF682J	5905-279-3503
R321	COMPOSITION, 150 KΩ ±5% 1/2 w	6100-4155	01121 RC20GF154J	5905-279-2522
R322	COMPOSITION, 5.1 KΩ ±5% 1/2 w	6100-2515	01121 RC20GF512J	5905-279-2019
R323	COMPOSITION, 20 KΩ ±5% 1/2 w	6100-3205	01121 RC20GF203J	5905-192-0649
R324	COMPOSITION, 20 KΩ ±5% 1/2 w	6100-3205	01121 RC20GF203J	5905-192-0649
R325	COMPOSITION, 5.1 KΩ ±5% 1/2 w	6100-2515	01121 RC20GF512J	5905-279-2019
R326	COMPOSITION, 7.5 KΩ ±5% 1/2 w	6100-2755	01121 RC20GF752J	5005-249-4195
R327	COMPOSITION, 13 KΩ ±5% 1/2 w	6100-3135	01121 RC20GF133J	5905-279-2669
R328	COMPOSITION, 47 KΩ ±5% 1/2 w	6100-3475	01121 RC20GF473J	5905-254-9201
R329	COMPOSITION, 680 Ω ±5% 1/2 w	6100-1685	01121 RC20GF681J	5905-195-6791
R330	COMPOSITION, 6.2 KΩ ±5% 1/2 w	6100-2625	01121 RC20GF622J	5905-279-2673
R331	COMPOSITION, 820 Ω ±5% 1/2 w	6100-1825	01121 RC20GF821J	5905-171-1999
R332	COMPOSITION, 6.2 KΩ ±5% 1/2 w	6100-2625	01121 RC20GF622J	5905-279-2673
R333	COMPOSITION, 20 KΩ ±5% 1/2 w	6100-3205	01121 RC20GF203J	5905-192-0649
R334	COMPOSITION, 220 KΩ ±5% 1/2 w	6100-4225	01121 RC20GF224J	5905-192-0667
R335	FILM, 34.8 KΩ ±1% 1/8 w	6250-2348	75042 CEA, 34.8 KΩ ±1%	5905-892-6968
R336	POTENTIOMETER, COMPOSITION, 50 KΩ ±20%	6040-0900	01121 FWC, 50 KΩ ±20%	5905-072-7724
R337	COMPOSITION, 47 KΩ ±5% 1/2 w	6100-3475	01121 RC20GF473J	5905-254-9201
R338	POTENTIOMETER, 10 KΩ ±5%	0971-4240	24655 0971-4240	5905-918-2275
R339	FILM, 3.01 KΩ ±1% 1/8 w	6250-1301	75042 CEA, 3.0 1KΩ ±1%	5905-702-5974
R340	FILM, 100 KΩ ±1% 1/8 w	6250-3100	75042 CEA, 100 KΩ ±1%	5905-577-6743
R341	FILM, 100 KΩ ±1% 1/8 w	6250-3100	75042 CEA, 100 KΩ ±1%	5905-577-6743
R342	FILM, 68.1 KΩ ±1% 1/8 w	6250-2681	75042 CEA, 68.1 KΩ ±1%	5905-685-9821
R343	FILM, 140 KΩ ±1% 1/8 w	6250-3140	75042 CEA, 140 KΩ ±1%	
R344	COMPOSITION, 300 KΩ ±5% 1/2 w	6100-4305	01121 RC20GF304J	5905-185-6859
R345	COMPOSITION, 47 KΩ ±5% 1/2 w	6100-3475	01121 RC20GF473J	5905-254-9201
R346	FILM, 3.01 KΩ ±10% 1/8 w	6250-1301	75042 CEA, 3.01 KΩ ±10%	5905-702-5974
R501	COMPOSITION, 1 KΩ ±10% 1 w	6110-2109	01121 GB, 1KΩ ±10%	
R502	COMPOSITION, 390 Ω ±5% 1/2 w	6100-1395	01121 RC20GF391J	5905-279-1890
R503	COMPOSITION, 390 Ω ±5% 1/2 w	6100-1395	01121 RC20GF391J	5905-279-1890
R504	COMPOSITION, 390 Ω ±5% 1/2 w	6100-1395	01121 RC20GF391J	5905-279-1890
R505	COMPOSITION, 5.1 KΩ ±5% 1/2 w	6100-2515	01121 RC20GF512J	5905-279-2019
R506	FILM, 33.2 KΩ ±1% 1/8 w	6250-2332	75042 CEA, 33.2 KΩ ±1%	5905-681-8758
R507	FILM, 23.7 KΩ ±1% 1/8 w	6250-2237	75042 CEA, 23.7 KΩ ±1%	5905-702-0540
R508	COMPOSITION, 2 KΩ ±5% 1/2 w	6100-2205	01121 RC20GF202J	5905-190-8887

PARTS LIST (Cont.)

REF. NO.	DESCRIPTION	PART NO	FMC	MFG. PART NO.	FED. STOCK NO.
Continued					
R509	COMPOSITION, 6.2 KΩ ±5% 1/2 w	6100-2625	01121	RC20GF644J	5905-279-2673
R510	FILM, 38.3 KΩ ±1% 1/8 w	6250-2383	75042	CEA, 38.3 KΩ ±1%	5905-752-3316
R511	FILM, 33.2 KΩ ±1% 1/8 w	6250-2332	75042	CEA, 33.2 KΩ ±1%	5905-681-8758
R512	COMPOSITION, 6.8 K Ω ±5% 1/2 w	6100-2685	01121	RC20GF682J	5905-279-3503
R513	COMPOSITION, 240 Ω ±5% 1/2 w	6100-1245	01121	RC20GF241J	5905-279-2593
R514	COMPOSITION, 510 Ω ±5% 1/2 w	6100-1515	01121	RC20GF511J	5905-279-3511
R515	COMPOSITION, 510 Ω ±5% 1/2 w	6100-1515	01121	RC20GF511J	5905-279-3511
R516	COMPOSITION, 100 Ω ±5% 1/2 w	6100-1105	01121	RC20GF101J	5905-190-8889
CAPACITORS					
C101	TRIMMER, 0.8 - 8.5 pf	4910-1101	24655	4910-1101	5910-911-8073
C102	MICA, 24.9 pf ±2% 500 dcwv	4650-0024	00656	CM15E, 24.9 pF ±2%	
C103	PLASTIC, 0.00261 µf ±2% 200 v	4860-7331	84411	66µW, 0.00261 µF ±2%	
C104	TRIMMER, 8 - 50 pf	4910-1170	72982	557-051, 8 to 50 pF	5910-083-6446
C105	MICA, 215 pf ±2% 500 dcwv	4650-0321	72136	CM15E, 215pF ±2%	
C106	PLASTIC, 0.022 µf ±10% 100 v 100 dcwv	4860-7860	84411	663UW, 0.022 µF ±10%	5910-055-6119
C107	ELECTROLYTIC, 15 µf +100 - 10% 15 dcwv	4450-3700	37942	TT, 15 µF +100 -10%	
C108	ELECTROLYTIC, 60 µf +100 - 10% 25 dcwv	4450-2900	56289	D17872	5910-799-9280
C109	ELECTROLYTIC, 15 µf +100 - 10% 15 dcwv	4450-3700	37942	TT, 15 µF +100-10%	
C110	ELECTROLYTIC, 200 µf +100 - 10% 12 dcwv	4450-0400	37942	97679	5910-799-9281
C111	ELECTROLYTIC, 5 µf +100 - 10% 50 dcwv	4450-3900	37942	2040595S9C10x3	5910-448-5527
C112	ELECTROLYTIC, 15 µf +100 - 10% 15 dcwv	4450-3700	37942	TT, 15 µF +100 - 10%	
C200	MICA, 30 pf ±10%, 500 v	4620-0650	72136	CM15, 30 pF ±10%	
C201	MICA, 47 pf ±5%, 500 v	4640-0300	72136	CM15D470J	
C202	MICA, 10 pf ±10%, 500 v	4620-0100	72136	CM15, 10 pF ±10%	
C203	MICA, 556 pf ±1%, 300 v	4710-0628	14655	22A, 556 pF ±1%	5910-911-2755
C204	PLASTIC, 0.589 µf ±1% 100 v	4860-7992	84411	663UW, 0.589 µF ±1%	5910-902-5191
C205	PLASTIC, 0.0589 µf ±1% 100 v	4860-7866	84411	663UW, 0.0589 µF ±1%	5910-902-5188
C206	PLASTIC, 0.00589 µf ±1% 200 v	4860-7502	84411	663UW, 0.00589 µF ±1%	5910-902-5192
C207	PLASTIC, 0.00589 µf ±1% 200 v	4860-7502	84411	663UW, 0.00589 µF ±1%	5910-902-5192
C208	PLASTIC, 0.0589 µf ±1% 100 v	4860-7866	84411	663UW, 0.0589 µF ±1%	5910-902-5188
C209	PLASTIC, 0.589 µf ±1% 100 v	4860-7992	84411	663UW, 0.589 µF ±1%	5910-902-5191
C210	PLASTIC, 2.94 µf ±1% 100 v	4860-8380	84411	663UW, 2.94 µF ±1%	5910-907-6686
C211	PLASTIC, 2.94 µf ±1% 100 v	4860-8380	84411	663UW, 2.94 µF ±1%	5910-907-6686
C212	MICA, 930 pf ±2%, 300 v	4700-1130	14655	22A, 930 pF ±2%	5910-911-2767
C213	PLASTIC, 0.93 µf ±2%, 500 v	4860-7997	84411	663UW, 0.93 µF ±2%	5910-907-6615
C214	PLASTIC, 0.0930 µf ±2% 100 v	4860-7885	84411	663UW, 0.0930 µF ±2%	5910-902-7265
C215	PLASTIC, 0.00930 µf ±2% 100 v	4860-7590	84411	663UW, 0.00930µF ±2%	5910-902-5663
C216	MICA, 10 pf ±10%, 500 v	4620-0100	72136	CM15, 10 pF ±10%	
C217	MICA, 47 pf ±5%, 500 v	4640-0300	72136	CM15D470J	
C218	ELECTROLYTIC, 15 µf +100 - 10% 15 dcwv	4450-3700	37942	TT, 15 µF +100 - 10%	
C219	MICA, 10 pf ±10%, 500 v	4620-0100	72136	CM15, 10 pF ±10%	
C220	MICA, 39 pf ±5%, 500 v	4640-0200	72136	CM15D390J	
C221	MICA, 508 pf ±1%, 300 v	4710-0579	14655	22A, 508 pF ±1%	5910-912-1986
C222	PLASTIC, 0.00589 µf ±1% 200 v	4860-7502	84411	663 UW, 0.00589 µF ±1%	5910-902-5192
C223	PLASTIC, 0.0589 µf ±1% 100 v	4860-7866	84411	663 UW, 0.0589 µF ±1%	5910-902-5188
C224	PLASTIC, 0.589 µf ±1% 100 v	4860-7992	84411	663 UW, 0.589 µF ±1%	5910-902-5191
C225	MICA, 930 pf ±2%, 300 v	4700-1130	14655	22A, 930 pF ±2%	5910-911-2767
C226	MICA, 93 pf ±2%, 500	4650-0180	72136	CM15E, 93 pF ±2%	
C227	PLASTIC, 0.0930 µf ±2% 100 v	4860-7885	84411	663 UW, 0.0930 µF ±2%	5910-902-7265
C228	PLASTIC, 0.00930 µf ±2% 100 v	4860-7590	84411	663 UW, 0.00930 µF ±2%	5910-902-5663
C229	PLASTIC, 0.00682 µf ±1% 200 v	4860-7506	84411	663 UW, 0.00682 µF ±1%	5910-902-5195
C230	PLASTIC, 0.0682 µf ±1% 100 v	4860-7867	84411	663 UW, 0.0682 µF ±1%	5910-902-5189
C231	PLASTIC, 0.682 µf ±1% 100 v	4860-7993	84411	663 UW, 0.682 µF ±1%	5910-902-5190
C232	PLASTIC, 3.41 µf ±1% 100 v	4860-8410	84411	663 UW, 3.41 µF ±1%	5910-907-6616
C233	PLASTIC, 3.41 µf ±1% 100 v	4860-8410	84411	663 UW, 3.41 µF ±1%	5910-907-6616
C234	ELECTROLYTIC, 15 µf +100 - 10% 15 dcwv	4450-3700	37942	TT 15 µF +100-10%	
C235	MICA, 10 pf ±10%, 500 v	4620-0100	72136	CM15, 10 pF ±10%	
C236	MICA, 39 pf ±5%, 500 v	4640-0300	72136	CM15D470J	
C237	MICA, 47 pf ±10%, 500 v	4620-0700	00656	CM15B470K	5910-931-0531
C238	MICA, 30 pf ±10%, 500 v	4620-0650	72136	CM1530 pF ±10%	
C239	MICA, 30 pf ±10%, 500 v	4620-0650	72136	CM1530 pF ±10%	
C240	MICA, 30 pf ±10%, 500 v	4620-0650	72136	CM1530 pF ±10%	
C241	CERAMIC, .0047 µf +80%-20%	4405-2479	72982	801, 0.00 47 µF + 80-20%	

PARTS LIST (Cont.)

REF. NO.	DESCRIPTION	PART NO.	FMC	MFG. PART NO.	FED. STOCK NO.
CAPACITORS					
C242	CERAMIC, .0047 µf +80%-20%	4405-2470	72922	801,0.00 47µF +80-20%	
C243	CERAMIC, .0022 µf +80%-20%	4405-2229	72982	831,0.0022µF + 80-20%	
C300	MICA, 390 pf ±10%, 500 v	4700-0576	14655	22A, 390 pF ±10%	
C301	ELECTROLYTIC, 15 µf +100 - 10% 15 dcwv	4450-3700	37942	TT, 15 µF +100-10%	
C302	ELECTROLYTIC, 5 µf +100 - 10% 50 dcwv	4450-3900	37942	204059S9C10 x 3	5910-448-5527
C303	ELECTROLYTIC, 15 µf +100 - 10% 15 dcwv	4450-3700	37942	TT, 15 µF +100-10%	
C304	ELECTROLYTIC, 200 µf +100 - 10% 6 dcwv	4450-2610	37942	TT, 200 µF +100-10%	5910-945-1836
C305	ELECTROLYTIC, 15 µf +100 - 10% 15 dcwv	4450-3700	37942	TT, 15 µF +100-10%	
C306	ELECTROLYTIC, 5 µf +100 - 10% 50 dcwv	4450-3900	37942	2040595S9C 10 x 3	5910-448-5527
C307	ELECTROLYTIC, 200 µf +100 - 10% 6 dcwv	4450-2610	37942	TT, 200 µF +100-10%	5910-945-1836
C308	ELECTROLYTIC, 60 µf +100 - 10% 25 dcwv	4450-2900	56289	D17872	5910-799-9280
C309	ELECTROLYTIC, 1 µf ±20% 35 v	4450-4300	56289	15D105x0035A2	5910-726-5003
C310	ELECTROLYTIC, 60 µf +100 - 10% 25 dcwv	4450-2900	56289	D17872	5910-799-9280
C311	ELECTROLYTIC, 200 µf +100 - 10% 15 dcwv	4450-2610	37942	TT200 µF +100-10%	5910-945-1836
C312	ELECTROLYTIC, 60 µf +100 - 10% 25 dcwv	4450-2900	56289	D1872	5910-799-9280
C313	ELECTROLYTIC, 60 µf +100 - 10% 25 dcwv	4450-2900	56289	D1872	5910-799-9280
C314	PLASTIC, 0.00154 µf ±1% 200 v	4860-7317	84411	663UW, 0.00154 µF ±1%	5910-902-5194
C315	PLASTIC, 0.00154 µf ±1% 200 v	4860-7317	84411	663UW, 0.00154 µF ±1%	5910-902-5194
C316	MICA, 48.7 pf ±2%, 500 v	4650-0090	72136	CM15E, 48.7 pF ±2%	
C501	ELECTROLYTIC, 25 µf +100 - 10% 100 dcwv	4450-5596	80183	DEE, 25 µF +100-10%	
C502	ELECTROLYTIC, 50 µf +100 - 10% 50 dcwv	4450-2200	80183	TT, 50 µF +100-10%	5910-799-9283
C503	ELECTROLYTIC, 25 µf +100 - 10% 50 dcwv	4450-3000	56289	D33883	5910-799-9285
C504	ELECTROLYTIC, 10 µf +100 - 10% 25 dcwv	4450-3800	56289	30D106G025BB4M1	5910-952-8658
C505	ELECTROLYTIC, 22 µf ±20% 15 v	4450-5300	56289	150D226x0015B2	5910-752-4270
C506	ELECTROLYTIC, 5 µf +100 - 10% 50 dcwv	4450-3900	37942	2040595S9C 10 x 3	5910-448-5527
C507	ELECTROLYTIC, 6.8 µf ±20% 35 dcwv	4450-5000	56289	150D685x0035B2	5910-814-5869
DIODES AND RECTIFIERS					
CR301	IN34AS	6082-1003	58854	IN34A(s)	5961-170-4430
CR302	IN34AS	6082-1003	58854	IN34A(s)	5961-170-4430
CR303	IN34AS	6082-1003	58854	IN34A(s)	5961-170-4430
CR304	IN34AS	6082-1003	58854	IN34A(s)	5961-170-4430
CR305	IN645	6082-1016	24446	IN645	5961-944-8222
CR306	IN645	6082-1016	24446	IN645	5961-944-8222
CR307	IN645	6082-1016	24446	IN645	5961-944-8222
CR308	IN645	6082-1016	24446	IN645	5961-944-8222
CR309	IN645	6082-1016	24446	IN645	5961-944-8222
CR501	IN3253	6081-1001	79089	IN3253	5961-814-4251
CR502	IN3253	6081-1001	79089	IN3253	5961-814-4251
CR503	IN3253	6081-1001	79089	IN3253	5961-814-4251
CR504	IN3253	6081-1001	79089	IN3253	5961-814-4251
CR505	IN965B	6083-1015	07910	IN965B	5960-877-6192
CR506	IN957B*	6083-1038	28959	IN957B	
CR507	IN959B*	6083-1037	07910	IN959B	

*30 µv max. noise in 40 kc band with 0.5 ma bias.

PARTS LIST (Cont.)

REF. NO.	DESCRIPTION	PART NO.	FMC	MFG. PART NO.	FED. STOCK NO.
TRANSISTORS					
Q101	C6601	8210-1032	12498	C6601	
Q102	2N520A	8210-5200	72699	2N520 A Br.	
Q103	2N445A	8210-4451	93916	2N445A	5960-828-0776
Q104	2N1374	8210-1374	96214	2N1374	
Q105	2N445A	8210-4451	93916	2N445A	
Q106	2N445A	8210-4451	93916	2N445A	
Q201	2N929	8210-1002	01295	2N929	5960-226-8578
Q202	2N1374	8210-1374	96214	2N1374	
Q203	2N445A	8210-4451	93916	2N445A	
Q204	2N929	8210-1002	01295	2N929	5960-226-8578
Q205	2N1374	8210-1374	96214	2N1374	
Q206	2N445A	8210-4451	93916	2N445A	
Q207	2N1374	8210-1374	96214	2N1374	
Q208	3391A	8210-1092	24454	2N3391A	
Q209	2N1374	8210-1374	96214	2N1374	
Q210	3391A	8210-1092	24454	2N3391A	
Q211	2N1374	8210-1374	96214	2N1374	
Q212	2N445A	8210-4451	93916	2N445A	
Q301	2N2349	8210-1021	01295	2N2349	5961-967-1343
Q302	2N445A	8210-4451	93916	2N445A	
Q303	2N2349	8210-1021	01295	2N2349	5961-967-1343
Q304	2N445A	8210-4451	93916	2N445A	
Q305	2N445A	8210-4451	93916	2N445A	
Q306	2N520A	8210-5200	72699	2N520A BR	
Q307	2N520A	8210-5200	72699	2N520A BR	
Q501	2N445A	8210-4451	93916	2N445A	
Q502	2N445A	8210-4451	93916	2N445A	
Q503	2N445A	8210-4451	93916	2N445A	
Q504	2N445A	8210-4451	93916	2N445A	
Q505	2N697	8210-1040	82219	2N697	5961-752-0150
MISCELLANEOUS					
B501	BATTERY, Gould Nat. 19.2 v/450B	8410-0410	25686	Gould Nat. 19.2V	
J101	JACK	4260-1032	82389	L111	
J301	JACK	4260-1032	82389	L111	
M301	METER	5730-1371	40931	ME-3	
PL501	POWER PLUG	4240-0702	24655	4240-0702	5935-993-9847
SO101	SOCKET	4230-2850	24655	4230-2850	
S101	SWITCH	7890-3180	24655	7890-3180	5930-911-3050
S102	SWITCH	7890-3180	24655	7890-3180	5930-911-3050
S103	SWITCH	7890-3181	24655	7890-3181	5930-911-2791
S201	SWITCH	7890-3182	24655	7890-3182	5930-911-9310
S202	SWITCH	7890-3183	24655	7890-3183	5930-911-3073
S301	SWITCH	1564-1710	24655	1564-1710	
T501	TRANSFORMER	0746-4420	24655	0746-4420	5950-911-8074
	Etched Circuit Assembly (Complete)	1564-2701	24655	1564-2701	
	Knob Assembly (FREQUENCY)	5520-5520	24655	5520-5520	
	Knob Assembly (BANDWIDTH and METER)	5500-5321	24655	5500-5321	
	Knob Assembly (FREQUENCY MULTIPLIER)	5500-5323	24655	5500-5323	
	Knob Assembly (BAND LEVEL)	5520-5420	24655	5520-5420	
	Knob (CAL Thumbset)	5540-2500	24655	5540-2500	
	Indicator (FREQUENCY)	5470-0651	24655	5470-0651	
	Cabinet Assembly, Complete	1564-3200	24655	1564-3200	
	Handle and Bracket Assembly	1564-2200	24655	1564-2200	

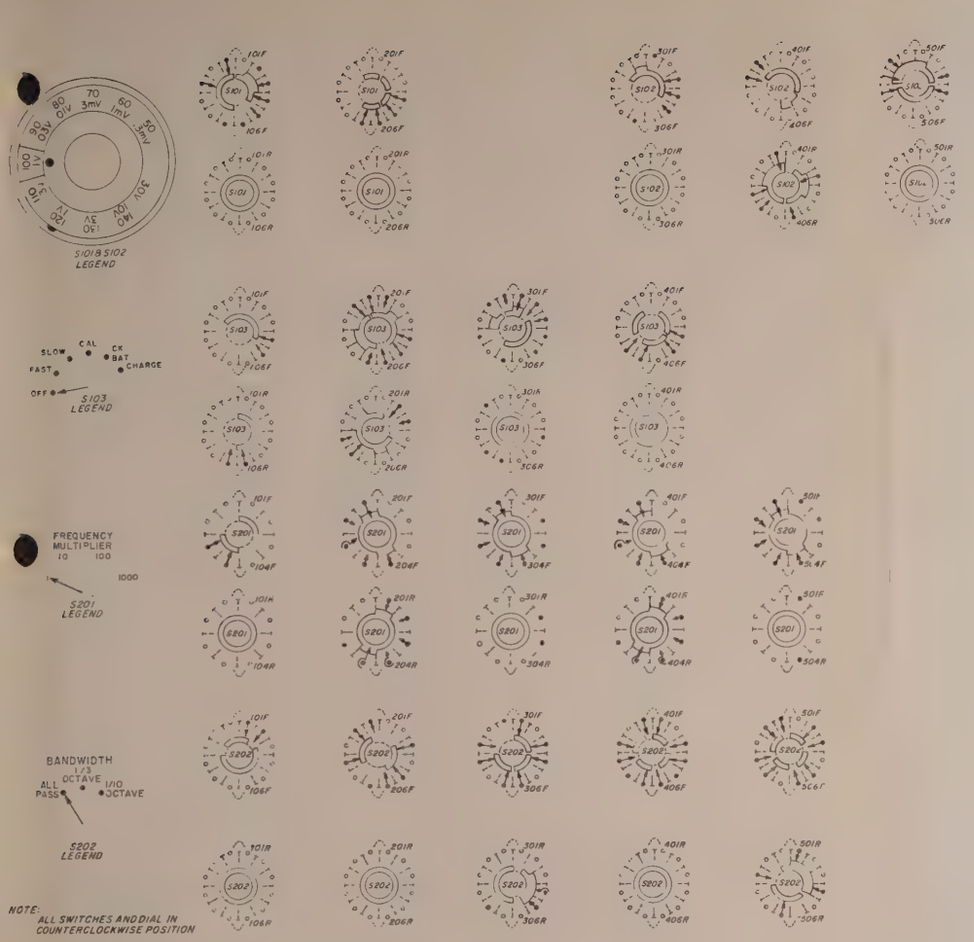
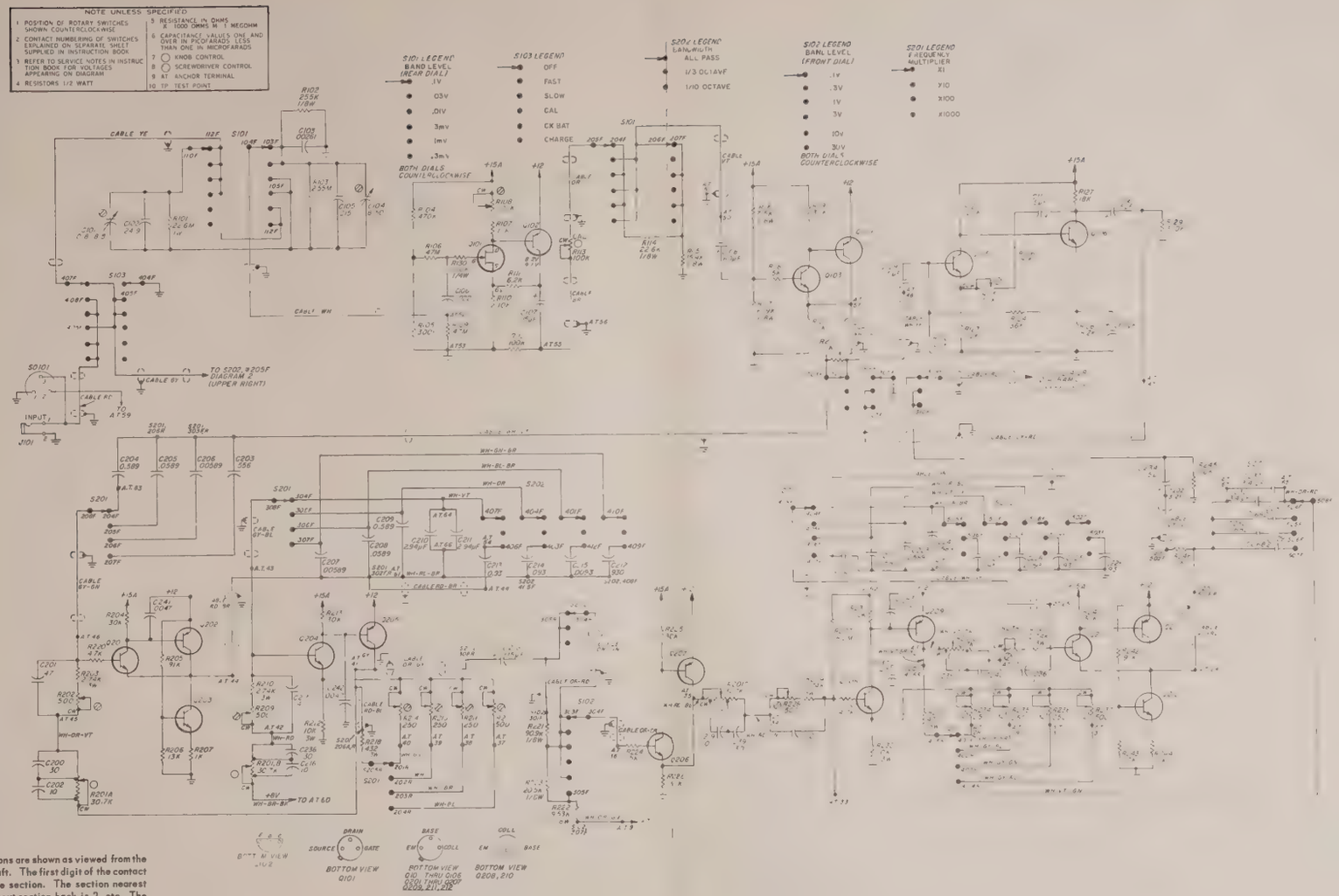


Figure 4-2. Rotary switch detail drawing.


NOTE UNLESS SPECIFIED
1 POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2 CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3 REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4 RESISTORS 1/2 WATT
5 RESISTANCE IN OHMS K - 1000 OHMS M - 1 MEGOHM
6 CAPACITANCE VALUES ONE AND OVER IN MICROFARADS LESS THAN ONE IN MICROFARADS
7 KNOB CONTROL
8 SCREWDRIVER CONTROL
9 AT ANCHOR TERMINAL
10 TP TEST POINT
S101 LEGEND (REAR DIAL)
S103 LEGEND
S204 LEGEND BANDWIDTH
S102 LEGEND (FRONT DIAL)
S201 LEGEND FREQUENCY MULTIPLIER
BOTH DIALS COUNTERCLOCKWISE
+15A
+12
-8V
INPUT
TO AT59
TO S202, 205F DIAGRAM 2 (UPPER RIGHT)
TO AT60
BOTTOM VIEW Q101
BOTTOM VIEW Q102 THRU Q105 Q201 THRU Q207 Q209, 211, 212
BOTTOM VIEW Q208, 210

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

Figure 4-3. Partial schematic diagram of Type 1564-A Sound and Vibration Analyzer. (See also Figure 4-5.)

NOTE: The number on the foil side is not the part number for the complete assembly. The dot on the foil at the transistor socket indicates the collector lead.

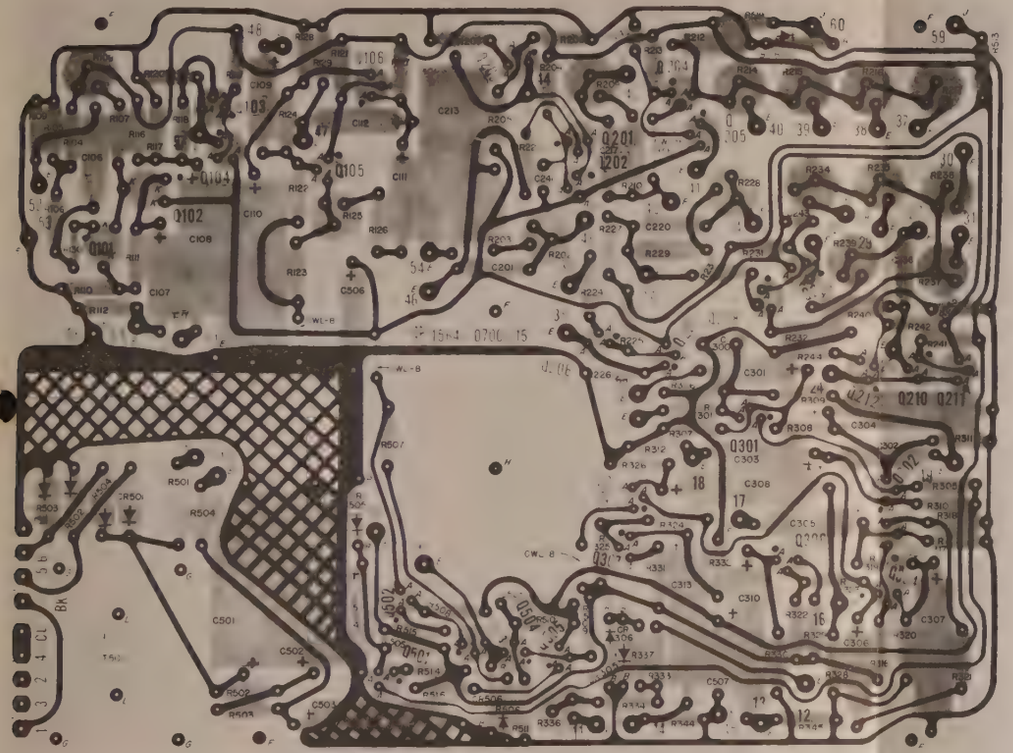


Figure 4-4. Etched-circuit board for Type 1564-A Sound and Vibration Analyzer. (Complete board assembly is P/N 1564-2701.)

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usuelly the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

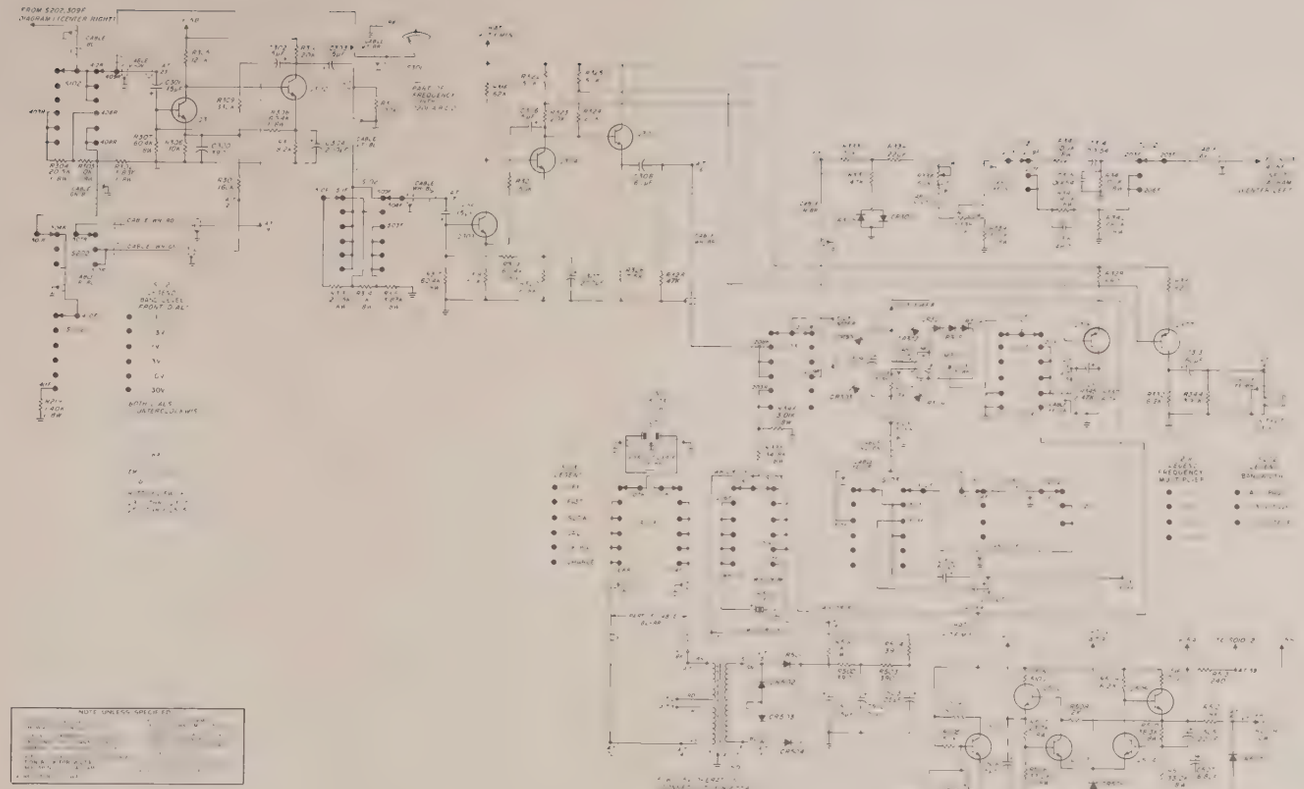
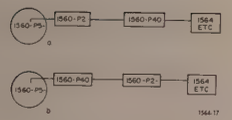


Figure 4-5. Partial schematic diagram of Type 1564-A Sound and Vibration Analyzer. (See also Figure 4-1.)



Appendix

VIBRATION MEASUREMENTS WITH THE TYPE 1564-A SOUND AND VIBRATION ANALYZER

The meter on the 1564-A reads directly in volts (or millivolts); it is therefore convenient to measure acceleration directly, because

$$\text{Acceleration (in g)} = \frac{\text{1564-A Meter Reading}}{\text{Sensitivity of Pickup (V/g)}}$$

The velocity and displacement can then be computed from the acceleration and the frequency.

$$\text{Velocity} = \frac{\text{Acceleration}}{2\pi f}$$

$$\text{Displacement} = \frac{\text{Acceleration}}{4\pi^2 f^2}$$

Any General Radio vibration pickup can be used directly with the 1564-A Analyzer. The high-frequency response will be determined by the resonant frequency of the pickup. The low-frequency response will be determined by the impedance of the pickup and the input impedance of the analyzer. The useful frequency ranges for the various pickups are given in the accompanying table.

If the 1560-P40 Preamplifier is used between the pickup and the analyzer, the effective sensitivity can be increased 10 to 1 and all pickups can be used down to 2.5 Hz.

If one wishes to use the control box to determine the velocity and displacement, the low-frequency limit in all cases is 25 Hz. The 1560-P40 Preamplifier can be used to increase the effective sensitivity, but it will not improve the low-frequency response appreciably, because this is limited by the control box. The connections and modifications necessary for the use of the preamplifier with the control box are given below.

The 1560-P40 Preamplifier can be used with the 1560-P2__ Control Boxes with no modification if the connections are made as shown in a.

When the control box follows the preamplifier, as in b, the following modifications must be made: A connection must be provided to supply power for the 1560-P40 Preamplifier, and the output of the preamplifier must be made to look like the 1560-P5__ Pickup.

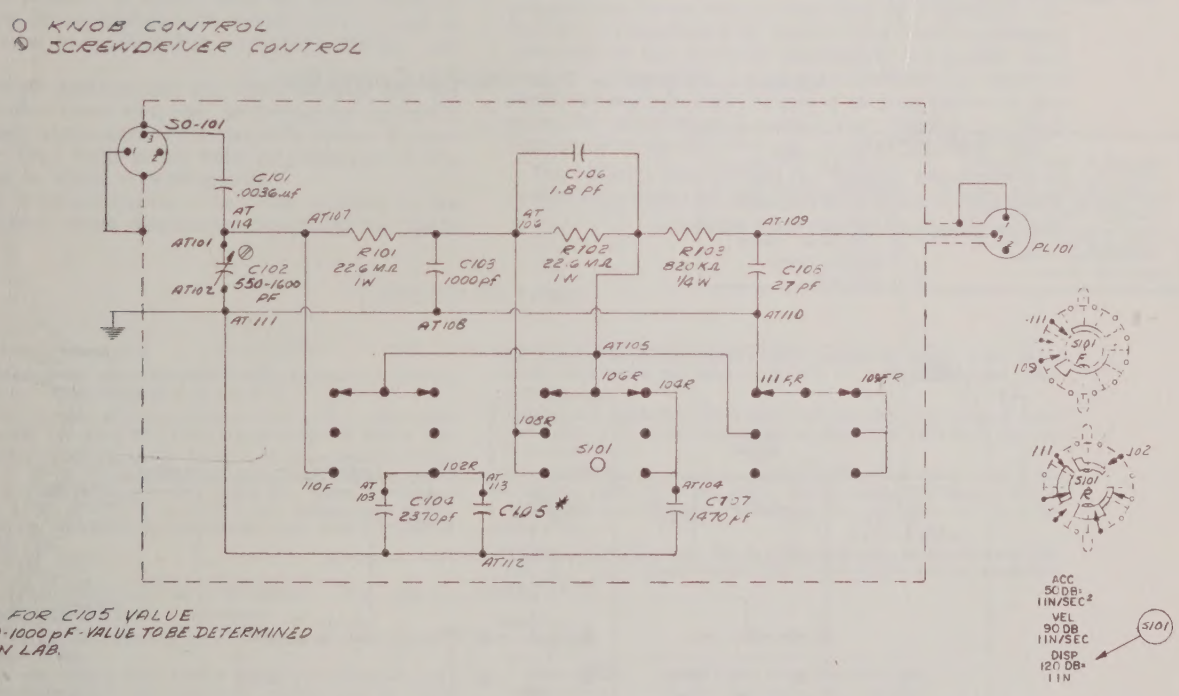
PICKUP TYPE NO.	NOMINAL SENSITIVITY (mV/g)	NOMINAL IMPEDANCE (pF)	RESONANT FREQUENCY (fo)	USEFUL FREQUENCY RANGE WITH 1564-A ANALYZER (Hz)
1560-P52	70	10,000	3200	2.5-1100
1560-P53	70	350	27,000	20-10,000
1560-P54	700	700	5000	20-1700

To provide the connection for power to the 1560-P40 preamplifier, replace the 1560-P2_output cable with a similar cable made from 2-wire shielded microphone cable (instead of single-conductor shielded (coax) cable). Use one of the two conductors to replace the single conductor of the original cable and connect the other from pin #2 of the OUTPUT plug to pin #2 of the INPUT socket of the 1560-P2_Control Box.

To provide the proper source impedance for the 1560-P2_Control Box, connect a capacitor in series with the input lead of the box. This capacitor must be equal to the capacitance of the appropriate vibration pickup plus its cable. Nominal values and the connection points for the three GR Vibration Systems are tabulated below. For best results, the measured value of the pickup capacitance including its connecting cable should be used.

VIB. MEAS. SYSTEM	CONTROL BOX	PICKUP	NOMINAL PICKUP CAP INC. CABLE	CONNECTION
1560-P11B	1560-P21B	1560-P52	.01 μF	IN SERIES WITH C101
1560-P13	1560-P23	1560-P53	525 pF	S0-101 #3 - AT 114
1560-P14	1560-P24	1560-P54	930 pF	S0-101 #3 - AT 114
1560-P11B	1560-P21B	1560-P52	.00265 μF*	S0-101 #3 - AT 114

*Series combination of .01 μF and .0036 μF so C101 can be replaced with .00265 μF.



Schematic diagram for Type 1560-P21B Control Box.

General Radio 300 BAKER AVENUE, CONCORD, MASSACHUSETTS 01742

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